BUS HUMPS OR VIRTUAL BUMPS OR BOTH?

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Abstract

Already in 1982, the Swedish Road Safety Office presented guidelines on speed-reducing devices including proposed design for roads with bus traffic and other heavy-vehicle traffic. However up to now a fully acceptable design of humps on streets with regular bus traffic does not seem to be available. Results from research on this topic from the Stockholm and Malmö areas in Sweden are summarised. Bus drivers’ comfort was measured when driving over three different types of humps, an ergo hump, a hump with a level upper surface, and a speed cushion. Neither of them fulfils the requirements set by the Swedish Work Environment Authority, but the speed cushion proved to be more comfortable than the other two for bus drivers. It is concluded that vehicle speeds should be 30 km/h or less wherever children (regularly) cross streets. However, if a pedestrian or bicyclist is hit by a truck or bus, the fatality risk is high at any speed. Therefore, measures are needed for children to see and be seen and measures are needed to improve orientation and create clarity. Telematics and other types of Intelligent Transportation Systems, ITS, seem to be needed to satisfy Pedestrian and bus drivers’ Quality needs. Intelligent Route Guidance Systems (for pedestrians), Advanced Driver Assistance Systems (ADAS), Intelligent pedestrian crossings and Intelligent Speed Adaption (ISA) were suggested by experts. But the only system fully developed at present is ISA, and so far political acceptance has not been enough to fulfil a large-scale implementation of ISA. The experts also suggested topics for future research. Finally, a proposal for a design of a case study is described.

Introduction

Studies show that children and elderly pedestrians have difficulties to account for the speed of approaching vehicles when making the decision to cross a street. Connely et al. (1998) found that especially children aged 8 to 9 often make very risky distance judgments; their distance gap thresholds remained constant regardless of vehicle approach speeds. Older pedestrians (older than say 70-75 years) accept shorter and shorter time gaps between approaching motor vehicles as motor vehicle speed increases (Oxley et al., 1997 and 2005; Lobjois and Cavallo, 2007). It is obvious that high speeds of motor vehicles are a serious problem at sites where pedestrians cross streets, especially if the pedestrians are children or elderly. A speed limit of 30 km/h is often suggested at such sites. There is today a consensus of how to design humps on residential streets. This paper focuses on discussing what actions should be taken to ensure safety for pedestrian and low motor-vehicle speeds on streets with frequent bus traffic including virtual bumps based on ITS.
Design of Bus Humps

Already in 1982, the Swedish Road Safety Office presented guidelines on speed-reducing devices including proposed design for roads with bus traffic and other heavy-vehicle traffic (Leden, Andersson and Källström, 1982). In that same year, experiments were conducted at Lund Institute of Technology with different hump designs’ influence on bus passenger comfort and safety at different speeds (Gårder, 1982). However, up to now a fully acceptable design of humps on streets with regular bus traffic does not seem to be available. Below follows results on research on this topic from the Stockholm and Malmö areas in Sweden.

The effects on bus drivers’ comfort and health when driving over three different types of humps were studied in the Stockholm area, an ergo hump, a hump with a level upper surface, and a speed cushion (Rosander, Lyckman and Johansson, 2007). The designs of the three types are illustrated in Figure 1. The total length of the ergo hump is about 11 m including two ramps of different lengths 1.7 m (when driving on to the hump) and 7 m (when driving off). The length of the hump with the level surface is about 12 m including two ramps of 2.2 m. The length of the speed cushion is 3.6 m, see Figure 2. Bus drivers’ comfort was measured. Neither of them fulfils the requirements set by the Swedish Work Environment Authority, but the speed cushion proved to be more comfortable than the other two for bus drivers. More than half of the bus drivers stated that due to frequent driving over the hump with level upper surface they suffered physically. The corresponding share for the ergo hump was one in four, while none stated that they got physical problems from driving over the speed cushions. One in five bus drivers stated that there are more effective alternatives than speed cushions to reduce speeds; 83% made this statement for the ergo hump and 95% for the hump with the level upper surface.

Figure 1. Ergo hump, Stockholm (1.7 m long s- ramp)  Hump with level upper surface, Stockholm (2.2 m long ramp)  Speed cushion, Malmö

Figure 2. Measures (m) for speed cushion. Height 7 cm.
All three types of humps had positive effects on motor-vehicle speeds, but the goal associated with traffic calming in Sweden was only reached for the site with the speed cushion; that the 90-percentile was brought below 30 km/h, see Table 1. The speed cushion was situated at an intersection, while the other two humps were situated on a section of road between two intersections.

Table 1. Motor vehicle speeds

<table>
<thead>
<tr>
<th>Type of hump</th>
<th>Ergo hump</th>
<th>Hump with level upper surface</th>
<th>Speed cushion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed limit (km/h)</td>
<td>30</td>
<td>30*</td>
<td>50 km/h</td>
</tr>
<tr>
<td>N</td>
<td>150</td>
<td>144</td>
<td>186</td>
</tr>
<tr>
<td>mean (km/h)</td>
<td>23.8</td>
<td>26.9</td>
<td>17.8</td>
</tr>
<tr>
<td>90-percentile (km/h)</td>
<td>32.0</td>
<td>38.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Standard error</td>
<td>5.31</td>
<td>8.18</td>
<td>5.77</td>
</tr>
<tr>
<td>Standard error for mean</td>
<td>0.43</td>
<td>0.68</td>
<td>0.42</td>
</tr>
</tbody>
</table>

* recommended speed

Pedestrians’ and bicyclists’ behaviour and safety were studied at the three locations, when they were crossing the street and had interactions with motor vehicle traffic. Almost every pedestrian and bicyclist regardless of age was given priority by approaching motor vehicle drivers.

Next, the research results from the Malmö area in Sweden are described. The street Regementsgatan in Malmö, Sweden, where similar speed cushions were installed in front of the marked pedestrian crosswalks as in the Stockholm area, has been studied at four time periods to be able to detect any changes of behaviour over time (Johansson, 2004). The 90-percentile of the vehicle speeds was 30 km/h or less at the studied sites two years after the reconstruction. About 80% of the children were given priority by approaching motor vehicle drivers. As expected, the share increased somewhat over time.

The share of children making head turns to detect oncoming cars and percent stopping at the curb before crossing the street were expected to decrease over time as the crossing task was expected to be easier to conduct. Such a behavioural adaptation was found at the reconstructed sites, but as there was a reduction also at the earlier reconstructed comparison site, the changes at the reconstructed sites can partly reflect general changes in behavior at reconstructed sites.

The hypothesis was that fewer children were expected to be running when entering and crossing the street two years after reconstruction compared to shortly after. However, the only significant difference observed was that more children ran across the street at one of the comparison sites.

It should also be mentioned that a special design for humps on roads with heavy-vehicle traffic is included in the guidelines from the Swedish Road Safety Office (Leden et al., 1982). The suggested design is a hump with a rounded upper surface and 1.5 m long ramps at a gradient of 1:20. The gradient for the speed cushions in the experiment described above with flat upper surface was 1:10. Perhaps the design and placement of the speed cushion is not optimal. Research by Johansson and Rosander (2008) suggests that speed cushions should be placed at a distance of 8-10 m from the crosswalk to be effective and not, as often is the case, at a distance of 4-5 m.

Johansson et al. (2004) conclude that vehicle speeds should be 30 km/h or less wherever children (regularly) cross streets. However if a pedestrian or bicyclist is hit by a truck or bus, the fatality risk is high at any speed (Leden, Gårder and Pulkkinen, 2000). Therefore, measures are needed for children to see and be seen and measures are needed to improve orientation and create clarity. Telematics and other types of Intelligent Transportation Systems, ITS, seem to be needed to satisfy pedestrian and bus drivers’ quality needs.
Intelligent Speed Adaption, ISA has been suggested, but so far political acceptance has not been enough to fulfil a large scale implementation. Therefore, more research is needed. To further elaborate on this topic, results of an expert questionnaire on how to satisfy pedestrian quality needs by means of telematics and other types of Intelligent Transport Systems, ITS, is summarized next.

**Expert questionnaire**

An expert questionnaire focusing on how to satisfy pedestrian quality needs by means of telematics and other types of Intelligent Transport Systems, ITS, was sent to 25 experts. Most of them are European. The questionnaire was distributed to the participants at the COST 358 PQN-committee meeting and at the ICTCT conference in Valencia in October 2007 as well as to colleagues in the HUMANIST network of excellence. Only four of the 25 experts were women. According to the experts, people walk because it is fun, then often accompanied by a friend; to get exercise, then often for health reasons; but often also - because there is just no other options. According to most experts, the key factor for making walking easy and attractive is a good design of the traffic system; giving short distances, shortcuts compared to the automobile system, well functioning intermodality, and an attractive pedestrian network. Only five experts mentioned safety and/or security as a factor making walking easy and attractive.

Expert were asked to describe at least one ITS measure that would improve the pedestrians’ situation the most, to comment on ITS concerning traffic safety for children travelling to/from school, and on ITS concerning safety and mobility for senior citizens. Intelligent Route Guidance Systems (for pedestrians), Advanced Driver Assistance Systems (ADAS), Intelligent pedestrian crossings and Intelligent Speed Adaption (ISA) were the solutions most often proposed. For example, cell phones could be equipped with Intelligent Route Guidance Systems. One example of such a system is TomTom. Intelligent pedestrian crossings could automatically detect and prioritise pedestrians and modify green light durations, which is typically needed for senior citizens, see e.g. www.walkinginfo.org/pedsmart/desits.htm. ADAS could include pedestrian detection and vision enhancement. Practical solutions are being developed, in projects like PREVENT, WATCHOVER and SAFESPOT. Different technologies are used to detect pedestrians. One of these are a wearable communication module or transmitter. Such transmitters can also be used when designing a system to ensure traffic safety for children travelling to and from school. One example is described in detail in the next section.

To enhance childrens’ safety, most often ADAS was proposed, while for senior citizens’ safety and mobility, Intelligent Route Guidance Systems, which could include an automatic emergency call (e-call), was most often proposed. For school childrens’ safety, special suggestions were made including having bus driver controlled signals to stop cars before the bus is arriving at a school bus stop. In the frame of the IN_SAFETY project, a corresponding intelligent system has been tested and patented in the US. The school bus sends out signals when stopping to activate a warning sign in approaching vehicles equipped with ADAS.

Finally, experts listed important future research questions, including the one which is elaborated on in the next section, e.g.:

- Vision enhancement by active pedestrian reflector triggered by head light of cars
- Impact of ITS on interactions between road users; and on mobility.
- Behavioural adaption to intelligent vehicle systems.
- How to keep elderly moving.
- Make the use of ITS (travel information systems, ticketing systems etc.) more user centered, so they can be used by senior citizens.
- How to ensure traffic safety for children travelling to/from school, which is the focus of the next topic.
Design of a case study to ensure traffic safety for children travelling to/from school

A typical experimental site feasible to be used for this case study would be a small school situated close to a rural road with high vehicle speeds, regular bus traffic, and a speed limit of, say, 50 km/h. School children have to cross the road, and are recommended to do it at a marked pedestrian crossing. They also walk along the road both on their way to and from school and at leisure time.

Variable speed message signs are installed as an alternative to conventional speed limit signs with an auxiliary sign indicating that the speed limit is valid at official school times. The variable signs have an auxiliary fixed “Reduce Speed” sign at a reasonable distance before the stretch of road with school children walking to and from school including the pedestrian crossing from both directions. The variable signs should be activated when needed, in principle when school children are present along the road or a pedestrian is to cross at the pedestrian crossing. The hypothesis is that safety will be improved with the alternative with variable speed message signs compared to conventional speed limit signs.

The signs are activated by means of two different systems. The first is tracking the schoolchildren. All school children have small transmitters (for example in a key ring), sending a signal, which is activating the system, i.e. lowering the speed limit, at a certain distance from the receiver at the pedestrian crossing. The lower speed limit is shown as long as a signal is received from any transmitter. There could be more than one receiver if there is a need to reduce speeds also when school children are approaching other locations. The second system is based on microwave or infrared surveying of a specified area around the pedestrian crossing. When the system detects a movement within the specified area the system is also activated and the lower speed limit is shown. When a signal is received from any of the two systems, the speed limit is changed to 30 km/h and the text “Reduce Speed” is shown. When no signal is received, the variable speed sign is turned off and the base speed, typically 50 km/h, is shown again after a certain threshold time of, for example, 20 seconds.

Data about when and from where the system was activated is stored. The system is designed so that the strategy from where the sign is activated can be modified to make it possible to survey and optimise the system. When implemented in full scale all sections in areas with a lot of children and/or senior citizens in the community should be equipped with variable message signs, or ADAS could be activated when triggered by pedestrians and cyclists.

Conclusions

For roads with bus traffic or other heavy-vehicle traffic, guidelines are missing for the design of speed reducing devices and/or Intelligent Traffic Systems to ensure safety and low speeds. Intelligent Route Guidance Systems (for pedestrians), Advanced Driver Assistance Systems (ADAS), Intelligent pedestrian crossings and Intelligent Speed Adaption (ISA) were suggested by experts. But the only system fully developed at present is ISA and so far political acceptance has not been enough to fulfil a large-scale implementation of ISA. Therefore, further research is needed in this area. This is urgent since a macro-based accident analysis study in Sweden suggests that the injury risk in marked, not traffic-calmed, crosswalks increased by 27% for pedestrians and 19% for cyclists compared to at unmarked locations after the code became stricter at marked crosswalks in Sweden. In other words, the legislative change led to lower safety even though the intent was to improve safety and mobility for pedestrians (Johansson, Gårder and Leden, 2004).
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Literature


