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NOISE AND NUISANCE FROM ROAD HUMPS

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ABSTRACT
The problems of noise and nuisance from vehicles passing road sections with road humps are addressed. Road humps are used on a big scale in Denmark as a tool to reduce speed and improve traffic safety. Therefore it is important to have knowledge about the consequences on noise and nuisance to those living along the road. For the first time noise, nuisance and driving pattern have been studied on the humps typically used in Denmark. The study shows speed reductions on road sections with humps. The noise is measured as SEL and as L_{AFmax} by the humps and on a road section between two humps. The noise is reduced in both positions. The highest reduction is found near the road humps. But questionnaires show, that neighbours feel more annoyed near the humps than between the humps.

1 - PROBLEM AND METHOD

Road humps are used as a tool to reduce speed and improve traffic safety. Humps are used on arterial streets with through traffic in urban areas. In some cases the neighbours have complained about the noise generated by the vehicles passing the humps. In this project these problems have been studied using an interdisciplinary approach. The following hypotheses have been set up partly based on a literature survey [2]:

1. On roads with humps the noise is generally reduced because of speed reductions.
2. There is a slight increase in the noise just before and after the humps, because vehicles especially trucks brake and accelerate as they pass the humps.

Eight road sections with 2 to 9 humps have been selected for the project (see table 1). The introduction of humps have reduced the speed by 5 to 14 km/h. Roads with 4 different speed classes are included. The results are shown separately for these 4 classes. All the humps are designed as so called "circle humps" where the cross section of the hump in the direction of the road describes a section of the surface of a circle. All the humps more or less fulfil the official Danish requirements for design of humps, and they are representative for newer Danish humps.

Road section	Length of section	Number of humps	Average distance between humps	Speed before	Speed by hump
Road-30	255 m	2	127 m	Unknown	33 km/h
Road-40-1	400 m	4	120 m	Unknown	32 km/h
Road-40-2	631 m	4	147 m	Unknown	33 km/h
Road-40-3	361 m	3	123 m	52 km/h	38 km/h
Road-50-1	872 m	4	249 m	52 km/h	47 km/h
Road-50-2	1563 m	6	274 m	61 km/h	50 km/h
Road-50-3	2219 m	9	252 m	59 km/h	52 km/h
Road-60	1037 m	4	281 m	66 km/h	55 km/h

Table 1: The road sections; the "speed before" was measured before the construction of humps.

It has been an important goal to ensure equal conditions on the selected road sections. The pavements of the road sections and the humps are dense asphalt concrete or surfaces with a similar surface structure. The noise is measured in free field conditions. There are no reflections from buildings or fences. The measurements have been normalised to a road surface temperature of 20 degrees Celsius. The only variable parameters defining the noise are believed to be differences in speed and driving pattern on the 8 road sections.
It has not been possible to carry out a before-and-after study because the road humps were already constructed when the project was started. Instead 3 different measuring positions have been selected on each road section:

1. A position just in the middle of a road hump, to represent the noise generated by vehicles passing the humps (termed "hump").

2. A position 10 m before/after the same hump, to represent the noise generated by vehicles braking before or accelerating after the hump (termed "10 m before").

3. A position situated in the middle of a road segment between two humps, to represent the noise generated by vehicles cruising at more or less constant speed (termed "middle").

The average speeds have been measured by radar before the construction of the humps. An expression of the noise (termed "before") covering the situation before construction of the humps has been predicted from the measurements in position 3 (middle) corrected to the speed before the humps were constructed. The Nordic Road Noise Prediction Method was used [3].
The microphone height was 1.2 m above ground, and all data have been normalised to a distance of 10 m from the road centre line. The Statistical Pass By Method was used for the measurements. The vehicles were divided into 4 categories: passenger cars, vans, trucks with two axles and trucks with more than two axles. 40 to 334 vehicles were included at each position. For each vehicle SEL and L_{AFmax} in octave bands and speed were measured and recorded in a data base. SEL has been predicted for a mixed traffic with 80 % passenger cars, 10 % vans, 9 % trucks with two axles and 1 % trucks with more than two axles (80/10/9/1).

2 - DRIVING PATTERN

Driving patterns have been registered using a measuring vehicle following randomly chosen vehicles. Driven distance and speed have been registered every second. The average driving patterns for passenger cars are shown in figure 1. There is a tendency towards more smooth driving pattern when the design speed of the road increases.

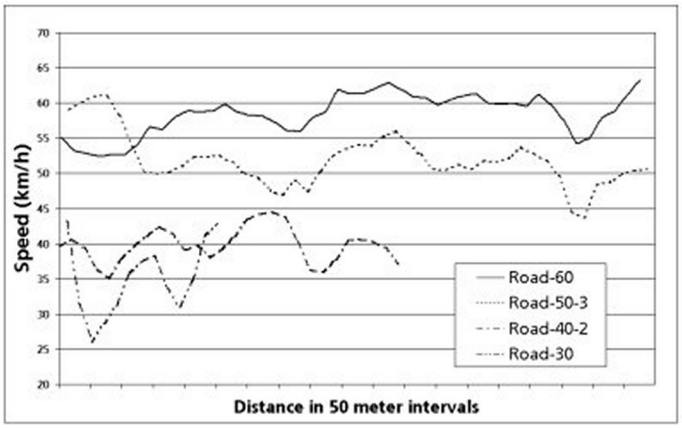

Figure 1: Measured average driving patterns for passenger cars on the different road types.

3 - RESULTS OF NOISE MEASUREMENTS

The main results can be seen in figure 2. The speed (see table 1) and the noise have been reduced after the introduction of humps. In the "middle" section the reduction were around 1 dB. By the humps the highest reductions of 2 to 4 dB are seen. By the low speed roads (30 and 40 km/h) the noise tends to be 2 to 4 dB higher 10 meters from the humps than by the humps. This must be caused by acceleration. The same tendencies are seen for all 4 vehicle categories. Looking at L_{AFmax} the same picture is seen.

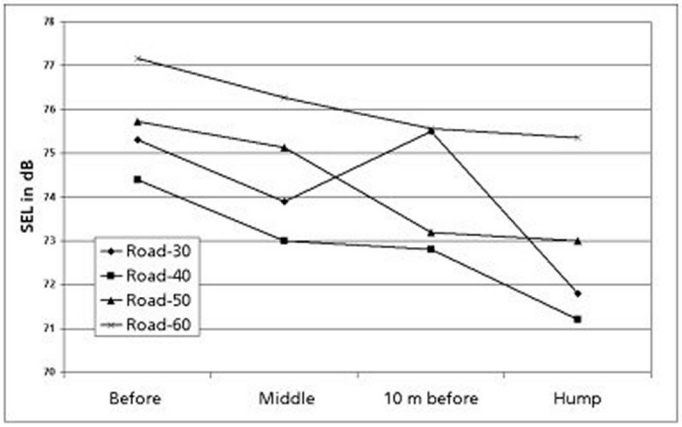

Figure 2: The noise measured as SEL for mixed traffic (80/10/9/1); the levels "before" the humps were constructed have been predicted.

4 - SOCIAL SURVEY

A questionnaire has been designed to study the reaction to noise by the people living next to the roads. All households situated in the first row along the roads included in the study have been handed a questionnaire. The households have been divided into two subgroups:

1. People living close to the road humps at a maximum distance of 20-30 m from a hump.
2. People living at a longer distance from the road humps.

The general reply rate was 78 %. The results can be seen in table 2. The general tendency shows a higher number of annoyed persons close to the road humps than in between the humps. By the 30 km/h road the result is opposite. Traffic volume and the $L_{Aeq,24h}$ are not the same on the different road categories. This is likely to be the reason for the big variation in degree of annoyance.

Speed category	Annoyed or very annoyed		Very annoyed	
	Near hump	Far from hump	Near hump	Far from hump
30 km/h	25 %	58 %	8 %	9 %
40 km/h	20 %	11 %	5 %	0 %
50 km/h	69 %	53 %	32 %	7 %
60 km/h	43 %	13 %	14 %	0 %

Table 2: The main results of the questionnaire survey; percentage of people answering yes to the question: "If you hear road traffic noise, is it annoying when you are inside your home with the windows closed?"; the answers have been summarised for each of the 4 speed categories.

5 - CONCLUSION

The first hypothesis is confirmed, as the noise (SEL) is generally reduced by 1 to 4 dB after construction of humps. The second hypothesis is also confirmed, as the noise is 0 to 4 dB higher 10 m before the humps than by the humps. Even though the noise is reduced people living very close to the humps tend to be more annoyed than people living between humps.

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