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ON THE NUMERICAL EFFECTS OF REPLACING SILENT ROADTYPES BY NON-SILENT ROADTYPES ON ROUNDABOUTS

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Abstract

Silent roads are very effective in abating traffic noise. However, their durability is limited due to less resistance to wear. Application, therefore, on a roundabout should be avoided. The numerical effects of replacing silent road types by non-silent road types on roundabouts have been calculated according the Dutch Noise Scheme extended with specific knowledge on the influence of roads on tyre and engine noise, respectively.

INTRODUCTION

In cooperation with the Dutch contractor BAM Infra, VANKEULEN Consultancy and Jansen Consulting Engineers have performed a research to the influence of the application of a durable road type on a crossing, sharp turn, and roundabout.

More and more, silent roads are applied in urban areas. Especially legislation put demands on noise reduction of roads. Characteristic for roads in urban areas is the occurrence of obstacles (i.e. crossings, roundabouts) that limits the traffic from freely flowing. In many cases these obstacles are combined with small radii and/or traffic lights. Near these obstacles low speeds and wringing traffic occur. Especially the latter is very unfavourable for silent roads because of their low resistance to wear. During the last years the durability of silent road types increased significantly, however, it is still not good practise to apply these road types near or on an obstacle.

Applying a durable road type near and on an obstacle instead has consequences for the noise immissions of adjacent dwellings. Since speeds are low near and on obstacles the noise reduction of the road type is little. Furthermore, vehicles are accelerating and decelerating which increases the engine noise of these vehicles. Silent roads mainly reduce rolling noise.

The goal of the present study was to calculate the increment of noise levels at façades near a road with an obstacle as accurate as possible. The calculations have been performed according the Dutch Noise Scheme [1] combined with recent data from literature on accelerating and decelerating vehicles. It was demanded that the overall effect on the façades should be less than 1 dB(A).

METHOD

Modelling

Calculation models have been made of a crossing, sharp turn and a roundabout (diameter 12.5 m). These three models have been used for light vehicles (passenger cars) as well as for heavy vehicles (lorries).

From literature [2] a value for acceleration and deceleration has been taken. For reasons of simplicity acceleration and deceleration values have been chosen identical. A low value of 2 m/s^2 has been chosen because that corresponds to the most unfavourable situation with respect to the elevation of noise immission on the façades. Low acceleration leads to low increase of engine noise relative to rolling noise and, therefore, the largest effect of the application of a durable road type.

The speed profile of a vehicle approaching an obstacle, passing the obstacle, and leaving the obstacle is based on elementary kinematics:

$$v(t) = a \cdot t + v_0 \tag{1}$$

$$x(t) = \tfrac{1}{2} a \cdot t^2 + v_0 \cdot t + x_0 \tag{2}$$

with a: acceleration (or deceleration)
v: speed
t: time
x: distance

This combined with the value from literature for the acceleration the speed as a function of distance has been derived which is shown graphically in the next figure.

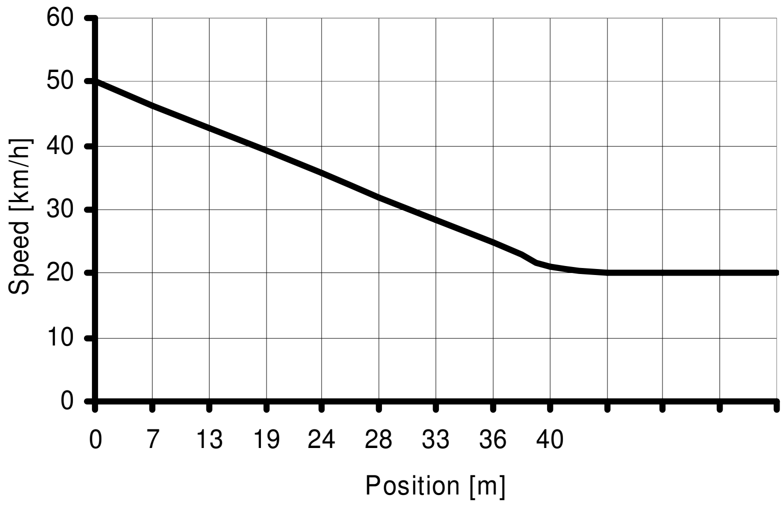

Figure 1 – Speed as a function of distance to or from the obstacle

From the above figure it can be seen that the chosen value for the acceleration (and therefore for the deceleration) of 2 m/s^2 the corresponding braking distance is 40 m. This distance is then divided in segments of 5 m. The segments located far away form the obstacles are 50 m long. Within a segment the speed is constant. In the next figure plots of the models are shown.

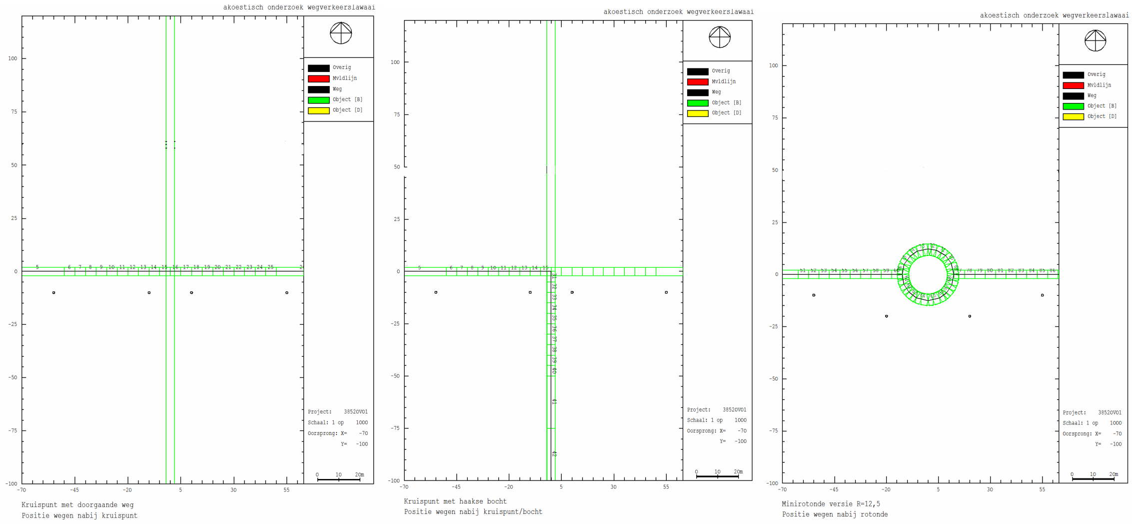

Figure 2 – Modelling of a crossing (left panel), sharp turn (middle panel), and roundabout (right panel)

Vehicle emissions

Since the speed in every segment is constant (see previous section) the corresponding noise emission relates to a free-flowing condition. In the Dutch Noise Scheme no other condition exists. Per segment the emission has been adapted as follows:

- The total noise emission has been divided in rolling noise and engine noise [3]. In figure 2 this division has been drawn for light and heavy vehicles, respectively.
- As a function of speed, the noise reduction of a silent road type Dubofalt (-5 dB(A) @ 50 km/h) relative to dense asphalt concrete (DAC) has been subtracted from the rolling noise.
- Dependent of speed and acceleration the extra emission of engine noise has been included [2]. At the roundabout itself this extra emission has been omitted since vehicles have a constant speed there.

Subsequently, all emissions from each segment and each vehicle category have been added for a number of observation points. Then these total immission values have been compared to those from the situation with DAC.

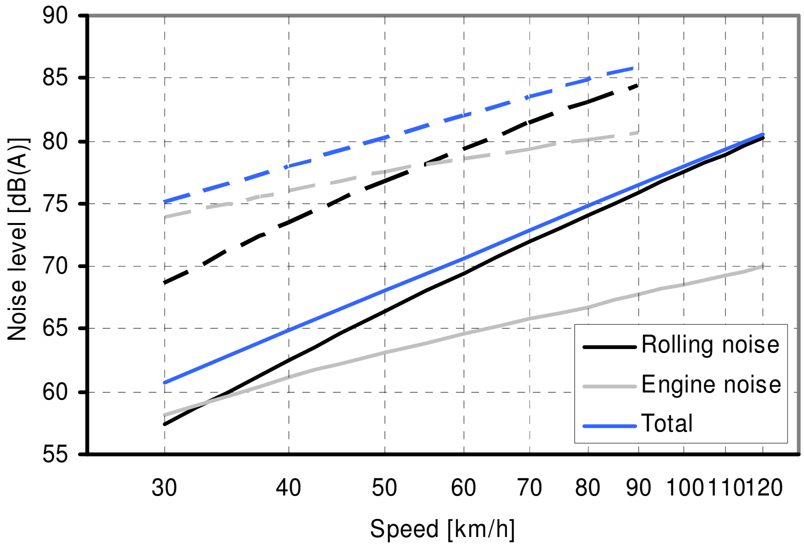

Figure 3 – The ratio between engine noise and rolling noise for light and heavy vehicles, respectively

The contribution of the emission of every segment to the immission of every observation point the logarithmic sum (indicated by the ⊕-operator) of the engine and rolling noise.

$$L_{tot,i,j,k} = L_{engine,i,j,k} \oplus L_{roll,i,j,k} \tag{3}$$

with L_{tot}: total immission
L_{engine}: engine noise
L_{roll}: rolling noise
i: vehicle category
j: segment
k: observation point

The engine and rolling noise are corrected with their respective effects from the road type:

$$L'_{tot,i,j,k} = (L_{engine,i,j,k} + \Delta L_{engine,i,j,k}) \oplus (L_{roll,i,j,k} + \Delta L_{roll,i,j,k}) \qquad (4)$$

with ΔL_{engine}: correction engine noise
ΔL_{roll}: correction rolling noise

The total difference of the noise immission of any observation point becomes:

$$\Delta L_{i,k} = \sum_j L'_{tot,i,j,k} - \sum_j L_{tot,i,j,k} \qquad (5)$$

In general, it can be concluded from eq. 5 the following:

1. The quieter the silent road type which is replaced by a durable one, the larger will be the effect on the façades.
2. The longer the part of the road with a durable road type to and from the obstacle, the larger will be the effect on the façades.
3. The lower the vehicle acceleration (deceleration), the larger will be the effect on the façades.
4. The closer the observation points are to the obstacle, the larger will be the effect on the façades.
5. For heavy vehicles the effects are smaller since with these types of vehicles the engine noise is relative higher than for light vehicles.

RESULTS

In this paper only results for roundabouts are presented since this kind of obstacles lead to the largest effects. Also only results for light vehicles are presented here (see point 5 previous section). In table I the differences of the noise immissions at the observation points due to the road type on a roundabout are presented. A positive number indicates an increment of the noise immission.

Table I – Increment of the noise immission near a roundabout

Observation point	increment noise immission [dB(A)]
1	0.0
2	0.2
7	1.1
8	1.0

5	1.0
6	0.8

From table I it can be seen that the increment is maximal 1.1 dB(A).

SENSITIVITY ANALYSIS

For a number of parameters their influence on the final result has been calculated. The following parameters have been analysed:

1. Distance of the observations points to the obstacle.
2. Increment of engine noise due to accelerating.
3. Length of the part of the road with a durable road type leading to and from the obstacle.

Distance

If the distance of the observation points is more than 10 m the increment is always less than 1.0 dB(A).

Increment engine noise

In the presented calculations an increment of the engine noise of 2 dB(A) due to accelerating has been adapted which is an unfavourable situation (see general conclusions number 3). In figure 3 the effect on the immission levels of various increments of engine noise is shown.

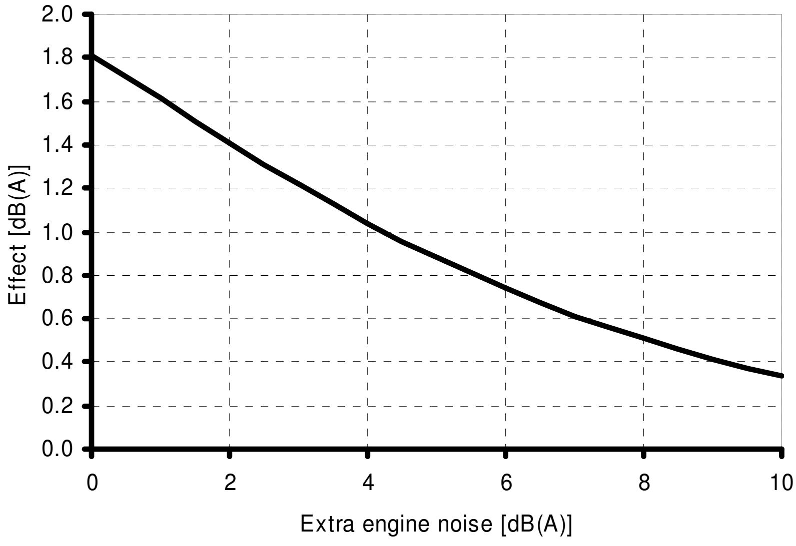

Figure 4 – Influence of the increment of engine noise

From figure 3 it can be seen that if the increment is 2 dB(A) or more then the effect on the façade is less than 1.4 dB(A) (or rounded 1 dB(A)).

Length part with durable road type

In the presented calculations the length of the part with a durable road type leading to and from the obstacle has been set to 40 m. which is an unfavourable situation (see general conclusions number 2). In figure 4 the influence on the immission levels of various lengths of this part is shown for two increments of engine noise.

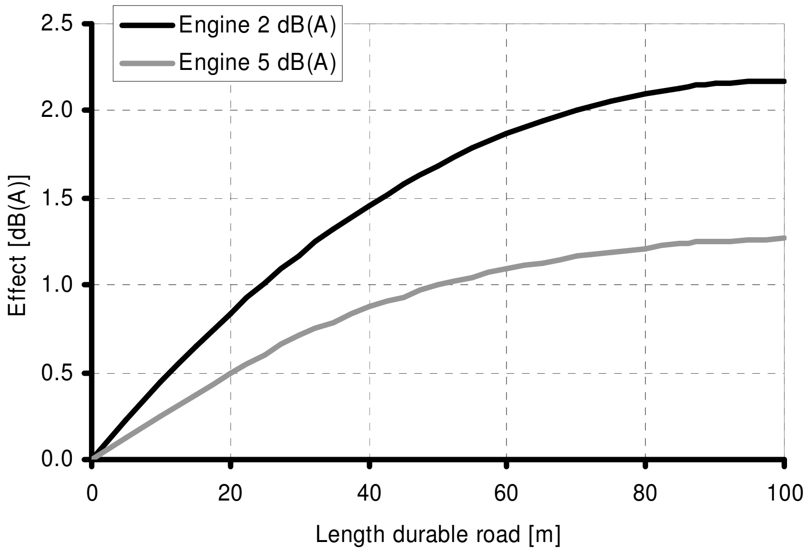

Figure 5 – influence of the length of the part of the road leading to and from the obstacle

From figure 4 it can be seen that if the total length of part with the durable road type is 40 m or less then the effect on the façade is less than 1.4 dB(A) (or rounded 1 dB(A)). If the increment of engine noise is 5 dB(A) then the effect is always less than 1.0 dB(A). If the length is limited to a more realistic value of 20 m than the effect is always less than 1,0 dB(A).

CONCLUSIONS

From calculations according the Dutch Noise Scheme adapted with recent data from literature, the following can be concluded:

- For heavy vehicles the effect on the noise immissions is always less than 1.0 dB(A).
- If the distance of the observation points is more than 10 m the increment is always less than 1.0 dB(A).
- If the increment of engine noise is 2 dB(A) or more then the effect on the façade is less than 1.4 dB(A).
- If the total length of part with the durable road type is 40 m or less then the effect on the façade is less than 1.4 dB(A). If the increment of engine noise is 5 dB(A)

then the effect is always less than 1.0 dB(A). If the length is limited to a more realistic value of 20 m than the effect is always less than 1,0 dB(A).

Generally, it can be concluded that the noise effects of replacing a silent road type by a durable type on an obstacle are 1 dB(A) or less. In these situations it is, therefore, useful to apply a durable road type.

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