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Road and Rail Infrastructure III

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THE IMPACT OF INTERSECTION TYPE ON TRAFFIC NOISE LEVELS IN RESIDENTIAL AREAS

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Abstract

Today road traffic noise represents one of the most serious environmental problems in urban areas. It is well known that the specific deceleration and acceleration dynamics of traffic at road intersections can cause different noise levels than free-flow traffic on open road segments. Also, each intersection type has variously distributed sections with different traffic flow conditions: constant speed, stop and go, deceleration and acceleration. The aim of research described in this paper is to establish whether the design of road intersection has influence on traffic noise emissions and to establish which intersection type is most suitable for application in urban areas, where residential buildings are often placed directly next to the noise source – in this case, the intersection. Models used for noise modeling in this research consist of two identical intersecting roads connected as follows, by mini roundabout and by intersection with or without traffic lights. Traffic noise calculations were conducted by means of specialized noise prediction software LimA using modified static noise calculation method RLS 90. Accuracy of roundabout noise model described in this paper had been verified in previous studies by comparison of measured noise levels and calculated noise levels on a number of urban roundabouts.

Keywords: intersection type, road traffic noise levels, traffic flow, noise modeling

1 Introduction

Today, in time of rapid technological progress and urbanization, and due to everyday exposure of population to high noise levels, negative effects of noise from various sources are increasingly noticed. Road traffic noise comprises an appreciable segment of total share of disturbance caused by noise in residential areas and therefore engineers are constantly working on finding new, more efficient and also most cost-effective protection measures that would reduce its levels to those prescribed by regulations.
It is well known that the specific dynamics of traffic flow at road intersections can influence local noise emission. Considering the fact that each intersection type has variously distributed sections with different traffic flow conditions (constant speed, stop and go, deceleration and acceleration) and the fact that vehicles under stop-and-go conditions produce more noise compared to traffic at a constant speed [1], it can be stated with certainty that traffic noise levels depend on intersection geometry and applied traffic regulation.
A problem with increased noise levels in the vicinity of intersections especially occurs in urban areas where residential buildings are placed right next to the road. Minor city streets are usually intersected by regular crossings with or without traffic lights and, lately, by roundabouts. In this paper, traffic noise modeling of these three most common types of urban road intersections is described. The road traffic noise analysis was conducted by means of specialized noise prediction software LimA using static German RLS 90 model, modified for the use in local

traffic conditions. Each testing model contains segments with different traffic flow conditions that correspond to real driving pattern through particular intersection type. The main goal of this study is to present the influence of certain intersection type on traffic noise emissions.

2 Traffic noise in the vicinity of road intersections

Generally, traffic noise situation can be determined by: field measurements, calculations conducted by means of specialised noise prediction software (noise modeling) or by combination of both measurements and calculation. For the purpose of this research, noise modeling procedure was carried out – noise modeling is most suitable method for comparison of various noise model scenarios, which is in this case a comparison of noise emissions in the vicinity of different road intersection types.

2.1 Road intersection noise modeling

Temporal and spatial variations in vehicle speed have a substantial impact on traffic noise emissions [2]. Depending on the way noise prediction models account for traffic flow, dynamic effects are more or less accurately captured. In static noise models, roads are divided into sections where the traffic flow is considered smooth and homogeneous. Since this assumption does not hold in the vicinity of intersections, some models include a propagation correction term.
In this research noise calculations were conducted by means of specialized software LimA using modified static German RLS 90 model. RLS 90 model includes the influence of road intersections on traffic noise levels by introducing propagation correction term for intersections with traffic lights, for up to a distance of 100 m from two nearest intersecting lane axis [3]. To capture the difference between noise levels of various intersection types it was necessary to make certain method modifications. Accuracy of modified RLS 90 noise model described in this paper had been verified in previous studies by comparison of measured noise levels and calculated noise levels on a number of urban roundabouts in Zagreb [4].

2.2 Intersection noise models

In order to investigate the impact of intersection type on traffic noise levels, three different noise models were designed:
- four leg intersection without traffic lights (priority to the right),
- four leg intersection with traffic lights and
- four leg mini roundabout.

Approaching legs of all testing models consist of identical two-lane two-way urban roads connected at an angle of 90°. Priority to right model and model with traffic lights have the identical intersection geometry. Mini roundabout was designed with circulatory roadway radius which occupies the same area as the first two regular intersections. The source of the traffic noise was situated at 0,5 m above the road surface in each lane axis and it was presumed that input traffic load was divided equally into all driving directions. Due to the comparability of results another assumption was that vehicles in roundabout drive only right, straight and left, excluding U-turn.
In modified RLS 90 model used in this research each lane axis is divided into segments with different traffic flow conditions (constant speed, stop and go, deceleration and acceleration) in accordance with real driving situation (Figure 1). Specific dynamics of traffic were defined by the average traffic speed of certain segment, and stopping and queuing by introducing traffic light position on each stopline and the entrance on the crossing area i.e. circulatory roadway. Identical input data on other noise emission parameters (vehicle speed, road surface type, longitudinal slope) and identical noise propagation parameters were defined for all testing models.

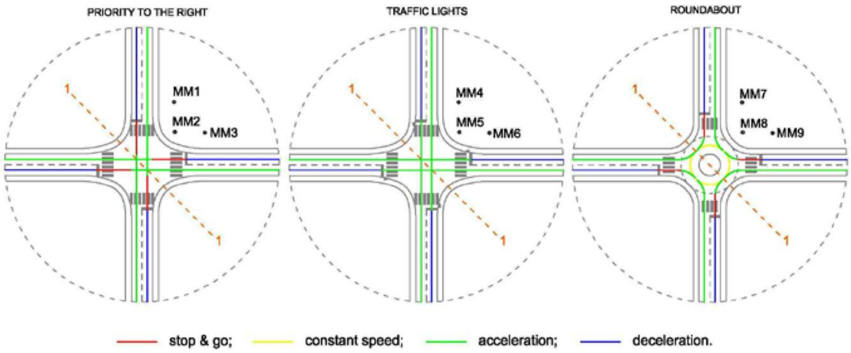


Figure 1 Intersection noise models

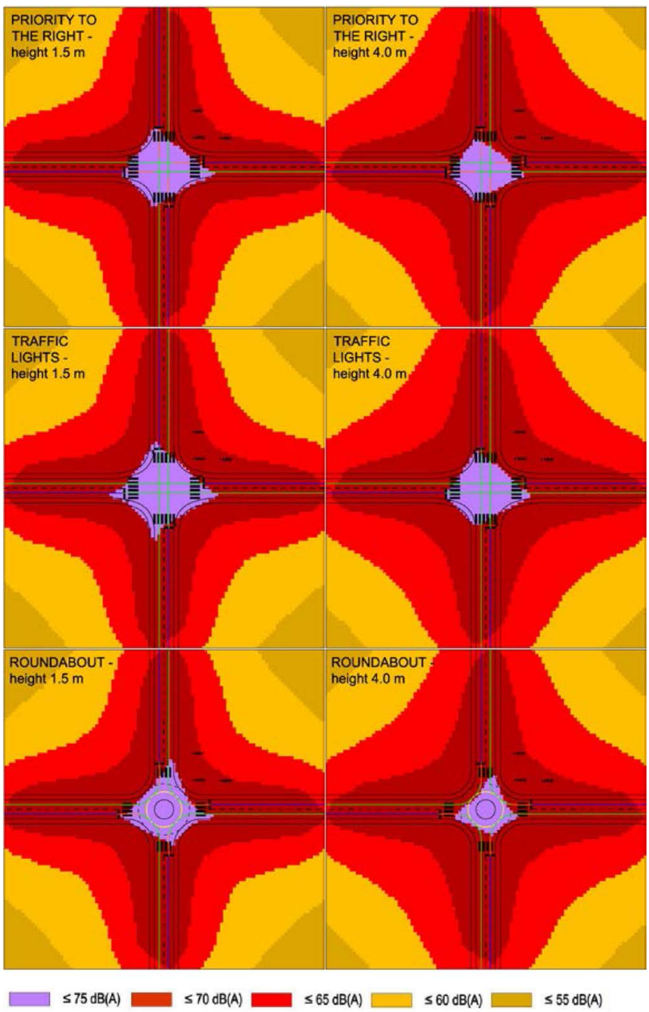


Figure 2 Predicted noise levels for period “day” for different intersection types

2.3 Noise prediction results

Traffic noise calculation procedure was carried out by means of specialized noise prediction software. All noise mapping simulation software packages have facilities to produce noise maps where receivers are arranged in a grid pattern following the terrain in a set height. In this research, noise prediction results were presented using noise maps (Figure 2) created at grid points defined by regulations [5] (grid 10x10 m at height of 1.5 and 4 m) and diagonal cross sections (Figure 3) showing predicted noise levels in intersection area to a height of 10 meters above driving surface.

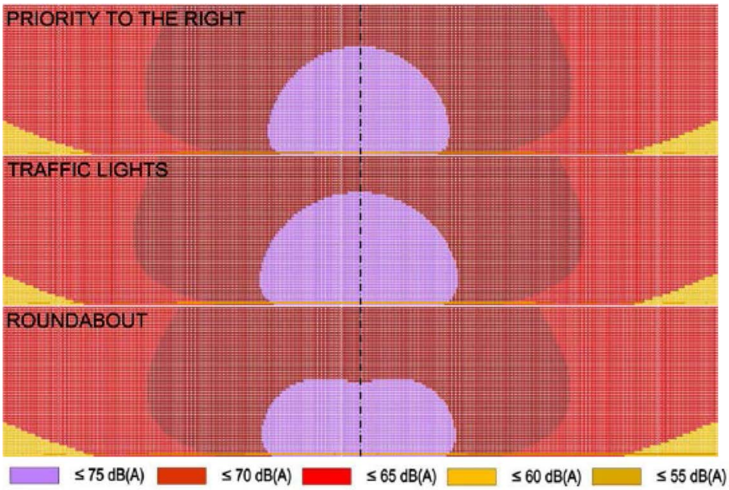


Figure 3 Predicted noise levels for period "day" at intersection diagonal cross-sections (1-1) in width of 50 meters

In Figure 4 comparison of resulting noise contours of all testing models is presented (noise results of all three intersections were folded through the centre of their axes).

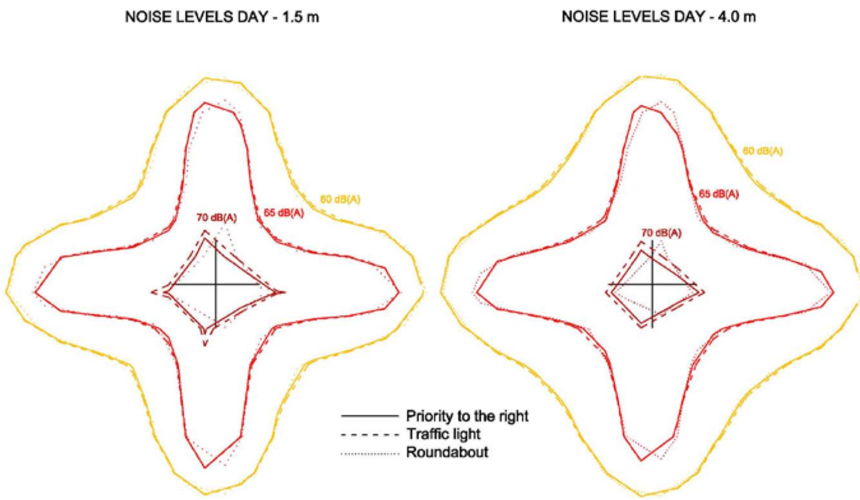
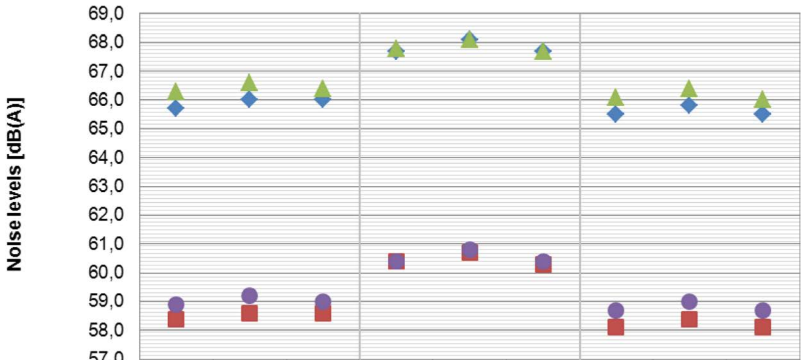


Figure 4 Comparison of noise prediction results

Beside the grid points, noise calculations were conducted in three free field receptors positioned at same locations for all testing models – at height of 1.2 m and 4.0 m, 7.5 meters from the axis of the lateral lane at entry and exit lanes and next to the intersection area. The results of these calculations are presented in Table 1.

Table 1 Traffic noise levels in free field receptors



	MM1	MM4	MM7	MM2	MM5	MM8	MM3	MM6	MM9
◆ Level day 1,2 m	65,7	66,0	66,0	67,7	68,1	67,7	65,5	65,8	65,5
■ Level night 1,2 m	58,4	58,6	58,6	60,4	60,7	60,3	58,1	58,4	58,1
▲ Level day 4,0 m	66,3	66,6	66,4	67,8	68,1	67,7	66,1	66,4	66,0
● Level night 4,0 m	58,9	59,2	59,0	60,4	60,8	60,4	58,7	59,0	58,7

2.4 Discussion

Noise prediction results showed that differences in predicted traffic noise levels between examined intersection types are not significant (they vary from 0 to 0.4 dB(A)), which can be seen from Figure 4. Previous studies [6] based on microscopic traffic simulations on a large number of simple intersection scenarios led to similar results: the intersection type was found to have a large influence on travel times, but only a small influence on global noise emission. Other studies [7] based on evaluation of noise conditions at intersections before and after conversion into a roundabout, including comparison of noise situation at regular intersection before reconstruction with activated and deactivated traffic lights, demonstrate that intersection with traffic lights has higher noise levels than roundabout (1.2 dB(A)) and intersection with traffic lights turned off (2 dB(A)).
Despite small differences in traffic noise levels given by noise modeling procedure in this research, it can be noticed that certain difference in noise emissions between examined intersection types does exist. Noise levels were highest at regular intersection with traffic lights (measuring points MM4, MM5 and MM6) while noise levels at intersection without traffic lights and mini roundabout were very similar – they vary from 0 to 0.1 dB(A) without any specific traceability.
The major advantage of roundabouts and intersections without traffic lights, with regard to decreasing traffic noise levels in the vicinity of crossroads, is a speed reduction and the fact that vehicles do not have to stop and wait under the traffic lights. In places near crossings regulated by traffic lights it is known that decelerating and accelerating traffic causes higher noise levels than free-flowing traffic because of higher engine noise levels. From aspect of intersection safety and traffic capacity, roundabouts are certainly more suitable for application in residential areas (compared to intersection without traffic lights), which is also one of the reasons why they became one of the most popular choices for intersections in urban areas. A noise problem that can occur in roundabouts is related to the application of overrun

areas with track aprons at the centre in order to allow heavy vehicles to pass the roundabout. If cars use these areas to drive through the roundabouts at high speed, this may generate high impulsive-like noise levels, which may additionally increase the overall noise levels.

3 Conclusion

Considering the fact that traffic noise became one of the most invasive types of noise pollution in residential areas and that traffic conditions at road intersections can lead to additional noise pollution compared to traffic at open road segments, it was necessary to examine if noise levels in the vicinity of road intersections can be reduced. The main goal of the research presented in this paper was to establish whether intersection design has any influence on noise emissions and in accordance with that to determine which intersection type is most suitable for application in urban areas.
Noise calculation results showed that there are no significant differences in predicted noise levels between three testing models. It was noticed that intersection with traffic lights produced highest noise levels. Despite the small differences in calculated noise levels on analysed models, reductions at roundabout and intersection without traffic lights compared to intersections with traffic lights are likely to depend upon the traffic flow conditions and the intersection layout. In accordance with that, further investigations on larger number of intersection models with different input parameters (other noise emission parameters, various intersection designs) are needed.

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