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7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



Organizer
University of Zagreb
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ROAD TRAFFIC NOISE MODELING AT ROUNDABOUTS

Saša Ahac, Vesna Dragčević

University of Zagreb, Faculty of Civil Engineering, Croatia

Abstract

It is well known that the specific dynamics of traffic at road intersections can greatly influence noise levels in urban and suburban areas. This is especially true when modeling noise at roundabouts, where temporal and spatial variations in vehicle kinematics can cause different noise levels than free-flow traffic on open road segments. Depending on the way noise prediction models account for traffic flow, these dynamic effects are more or less accurately captured. In this paper, a case study is presented, consisting of a road traffic noise level analysis in the vicinity of three suburban roundabouts in the City of Zagreb. Noise calculations were conducted by means of specialized noise prediction software using static and analytic noise models (modified RLS 90 and European interim method). Accuracy of the obtained noise contour maps was demonstrated by comparing the simulated and the observed noise levels at three receiver points along every roundabout. The aim of this research is to establish the level of reliability of applied noise models and to determine whether they can be used in road traffic noise prediction for suburban roundabouts in Croatia.

Keywords: noise modeling, roundabout, traffic flow, calculation methods

1 Introduction

Today road traffic noise is the main contributor to the excessive environmental noise levels in urban and suburban areas. Negative impact of traffic noise on residents is well known: it deteriorates human health, causing fatigue and reduced work capacity and also interferes with communication, concentration, relaxation and sleep. Practice has shown that due to the constant growth of population and associated increase in traffic loads, and despite the implementation of noise protection measures, overall noise levels in urban and suburban areas are increasing. Therefore, it is essential to systematically track changes in traffic noise levels and evaluate its impact on residents, which is possible by means of noise maps.

In the past two decades roundabouts became one of the most popular choices for intersections in suburban and urban areas adopted by town planners. According to the available data, in the year 2008 there were more than 130 roundabouts in Croatia, 85 of which were located in urban and suburban areas [1], and today there are over 30 modern roundabouts located in the City of Zagreb. Because of that, their influence on environmental noise levels should not be neglected. In this paper a case study is presented consisting of a road traffic noise level analysis in the vicinity of three roundabouts located in the suburban area of the City of Zagreb. Noise analysis included road traffic noise calculation by means of specialized software and two models used for road traffic noise prediction in Croatia: static German RLS 90 model (modified for the use in local traffic conditions) and analytic European interim model. In order to investigate accuracy of these models, calculated noise levels in the vicinity of analyzed roundabouts were compared with the noise levels measured *in situ*. The results of this study will help to establish the level of reliability of these noise models and to determine whether they can be used in road traffic noise prediction for suburban roundabouts in Croatia.

2 Road traffic noise modeling

The first step in the evaluation of traffic noise situation is the determination of noise levels and their presentation on noise maps. Methods used in the noise levels determination are: field measurements, calculations conducted by means of noise prediction software (noise modeling) and the combination of both measurements and calculation.

For the purpose of noise mapping, noise modeling is more suitable than field measurements. Measurements are very time consuming and can be carried out only under suitable weather conditions. Also, possible changes in future noise levels can only be determined by computer simulations. Production of a high quality computer model of the traffic noise emission and propagation is therefore a necessary prerequisite for prediction of road traffic impact on the noise situation.

2.1 Influence of intersections

The presence of an intersection results in the increase of noise levels in the surrounding area due to the change in the driving pattern of the vehicles, such as speed, acceleration or deceleration [2] – roundabouts are no exception. Temporal and spatial variations in vehicle kinematics at intersections can cause different noise levels than free-flow traffic on open road segments. Depending on the way noise prediction models account for traffic flow, these dynamic effects are more or less accurately captured.

In static noise models roads are divided into sections where traffic flow is considered smooth and homogeneous. When used in prediction of noise levels in the vicinity of an intersection these noise models usually include a propagation correction term, the value of which depends on the distance to the intersection. The influence of intersections on noise levels in the RLS 90 model can be included by a propagation correction term for intersections with traffic lights, for up to a distance of 100 m from the intersection [3].

Analytic noise models attempt to capture the impact of interrupted traffic on the average vehicle speed profile. They split each road section into subsections where vehicles are assumed to have a constant average speed and homogeneous traffic flow conditions [4]. With the European interim noise prediction model the influence of the intersection can be defined based on the decrease or increase of speed in relation to the mean traffic speed of the road. The type of traffic flow can be assumed as pulsated decelerated (upstream of the intersection) or pulsated accelerated (downstream of the intersection) [5].

Problems that emerge while modeling noise at roundabouts relate primarily to capturing the impact of their specific traffic flow conditions: minimized start-stop operations and queuing, smaller average speed of approaching and passing traffic with regard to signalized intersections. Methods presented in this paper are commonly used in Croatia for noise calculations on open road segments and signalized intersections, modified for application on roundabouts.

2.2 Location description and field measurements

Roundabouts presented in this paper are located on the edges of the fast growing suburban area on the west side of the City of Zagreb (Figure 1). In the immediate vicinity of the observed intersections residential and commercial facilities (shopping complex and a sports hall) are situated. Surrounding residential buildings are five to eight storeys high, while the height of nearby commercial facilities is approximately 20 m. In Table 1 basic geometric and design elements of analysed roundabouts are presented.



Figure 1 Location of analysed roundabouts.

In order to investigate the accuracy of analyzed noise models short-term (15 minutes) noise level measurements were done by three precise sound level meters at each roundabout at favourable meteorological conditions and height of 1,2 m above the ground surface. Measuring posts at each roundabout were placed at the distance of 7,5 m from the axis of the lateral lane at entry and exit lanes and next to the circulatory roadway (Figure 2). On each measuring post the measurements were repeated 3 times in the period 'day'. Results of these field measurements are shown in Figure 4. Traffic load for each road lane was determined by video recording of the traffic. This measurement has been done simultaneously with the noise measurement. Vehicles were divided in two groups: light and heavy vehicles. Traffic flow during field measurements was continuous; measurements during peak hour traffic were avoided because of possible traffic congestions.

Table 1 Basic geometric and design elements of analysed roundabouts.

Roundabout	Inscribed circle radius	Approach legs	Circulatory roadway width	Number of lanes on circulatory roadway
R1	32 m	2 two-lane; 1 single-lane	13,5 m	2
R2	23 m	3 two-lane	11 m	1
R3	25 m	4 two-lane	10 m	1

Data on the remaining noise emission parameters (road surface type, the longitudinal slope of road, vehicle speed, condition of traffic flow) and noise propagation parameters (relief, ground surface type, barrier and building height) for both noise models was collected during the reconnaissance of the area and then incorporated with digital 3D terrain model derived from available digital maps of the area (orthophoto and Urbanistic Master Plan of City of Zagreb).

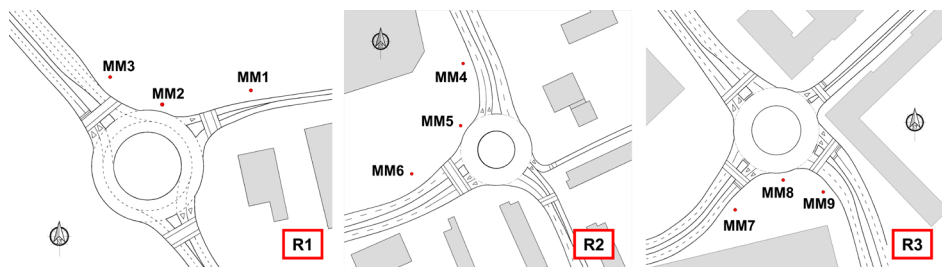


Figure 2 Location of measuring posts.

2.3 Noise models

When modeling traffic at roundabouts a spatial approach was used, in which lanes of intersection were divided into segments with different traffic flow conditions: constant speed, stop and go, deceleration, and acceleration (Figure 3). On each segment average speed of vehicle movement was determined by measuring the time of vehicle passage on the known length of road segment (it was presupposed that vehicles move at uniform speed). These values were applied in both noise prediction models. Additionally, in order to simplify the calculation procedure, in both models position of noise sources on circulatory roadway was assumed to be above carriageway axis. In order to adjust the traditional RLS 90 model to the local traffic conditions, following modifications were made: source of the traffic noise was situated at 0,5 m above the road surface for each axis of each individual lane on the roundabout legs, measured traffic load was divided equally over lanes and heavy vehicles were defined as vehicles with a total weight of 3,5 tons.

In the modified RLS 90 model different traffic flows were defined by the average speed observed on each segment. Influence of queuing and stopping of the vehicles on the approach legs of the roundabout was defined by introducing traffic light position on each stopline and entrance on the circulatory roadway. In the European interim noise prediction model influence of the intersection was defined by introducing the observed average speed and the type of traffic flow on each road segment (ie constant, stop and go, accelerated pulsated and decelerated pulsated flow).

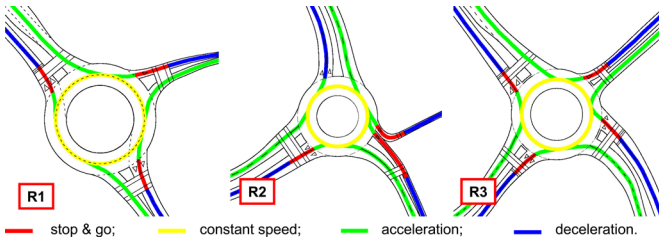


Figure 3 Segments with different traffic flow conditions and average speed.

2.4 Noise prediction results and model verification

The calculation of equivalent noise levels for the period 'day' was conducted by means of specialised noise prediction software LimA at the height of 1,2 m (due to the comparison to field measurement results) using modified RLS 90 model and European interim model. Results of these calculations are shown in Figures 4. and 5. The validity of the noise calculation model is determined by comparing the results of calculations and field noise measurements in corresponding measuring posts.

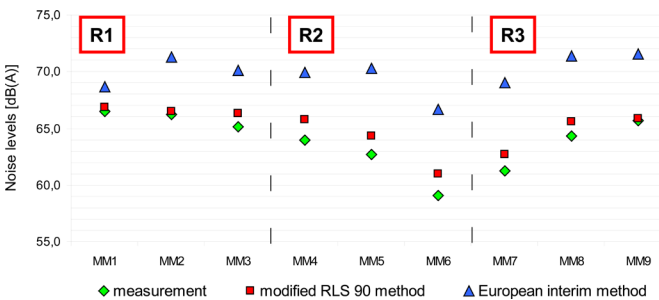


Figure 4 Measured and calculated noise levels in measuring posts.

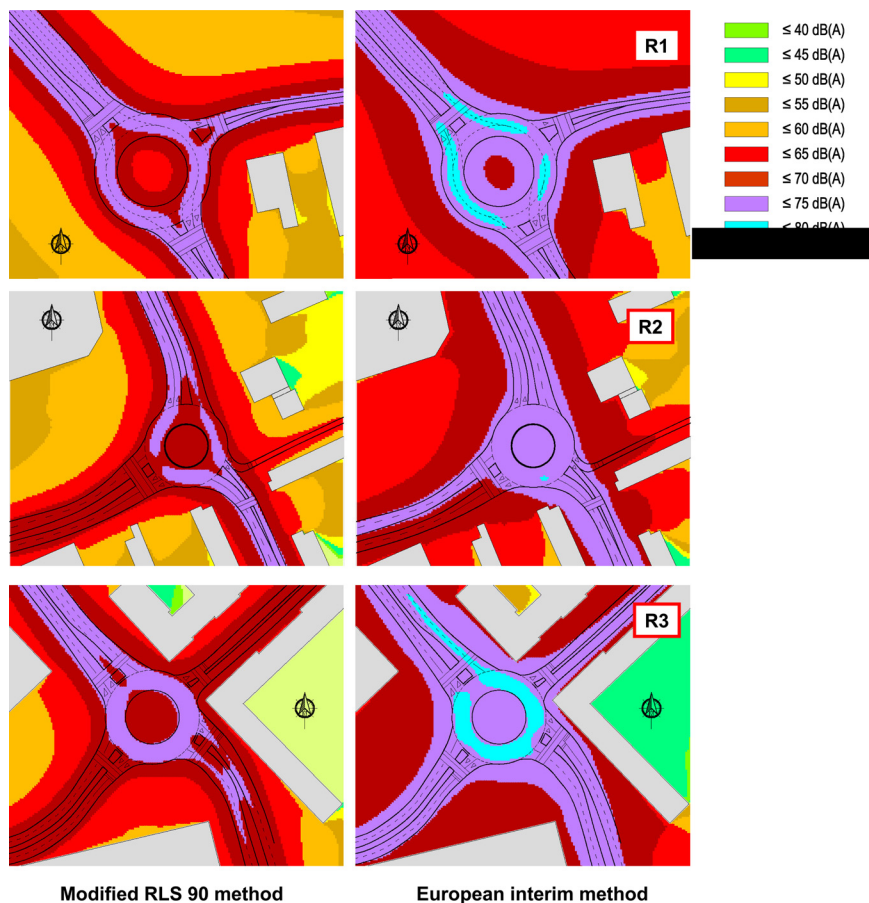


Figure 5 Predicted equivalent road traffic noise levels for the period 'day'.

Although the same input parameters for noise prediction were used in analysed models (such as traffic load, road surface type, the longitudinal slope of road, vehicle speed and type, etc.) substantial differences in the calculation results occurred, as shown in Figure 5. This departure can be explained by differences in noise emission and propagation modeling, ie differences in noise emission values for light and heavy vehicles (which are notable at lower speeds), differences in the assumptions concerning the road surface type, the longitudinal slope of road, meteorological conditions, modeling of the ground effect, interaction between the ground effect and screening [6, 7]. Also, studies have shown that increased complexity of model that includes more physical phenomena and effects, such as the impact of interrupted traffic on the average vehicle speed profile in analytic European interim model, will not automatically produce better results in terms of model accuracy [7].

Highest deviation from measured noise levels were recorded on the measurement posts at roundabout R2, and they stood at 2 dB(A). Meanwhile, the deviations of European interim model calculations results were significantly higher, reaching from 2 dB(A) on roundabout R1 to 8 dB(A) on roundabout R3. These results correspond to the results of previous studies conducted at the Department of Transportation on Faculty of Civil Engineering which included comparison of the calculated traffic noise levels for open road segments and signalized intersections [8, 9, 10]. Finally, all the calculated values were higher than the measured ones, which is favorable in terms of noise protection.

3 Conclusion

Roundabouts became very popular solutions for urban and suburban intersections. Problems that emerge while modeling road traffic noise in their vicinity prompted the investigation of the applicability of road traffic noise prediction models used in Croatia for noise calculations on roundabouts. These models are the static RLS 90 model (modified for the use in local conditions) and the analytic European interim model, which are intended primarily for calculation of road traffic noise on open road segments and signalized intersections. The RLS 90 model is often applied in noise calculations in practice because of its simplicity and tradition of use, while the European interim model is prescribed for noise calculations by the Regulations [11] for the purpose strategic noise mapping.

Analysis results showed that both models resulted in noise levels that were higher than measured ones (which is favorable in terms of noise protection), and that the results of modified RLS 90 model were closer to the measured noise levels. Therefore it can be concluded that modified RLS 90 model could be more suitable for noise prediction on roundabouts than European interim model. Although both methods provided the satisfying results in terms of noise protection, the question arises whether the use of complex interim method is justified in e.g. noise abatement projects. Since the analysis was conducted on a small number of examined cases, further investigations are needed in order to define the usability of both methods for the purpose of road traffic noise prediction in the vicinity of suburban roundabouts in Croatia.

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