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# NOISE LEVEL CONTROL ON A BUSY INTERSECTION

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## Abstract

In this paper, we will present the methods of reduction of traffic noise emitted from an intersection located in Zagreb, Croatia, specifically, the intersection between Slavonska Avenue and Marin Drzic Avenue. Both of these roads are multi-lane roads with high intensity traffic. Additionally, the Marin Drzic Avenue also has a tramway line in both directions located in the centre of the roadway. Due to the complexity of the roads in question and traffic intensity on both of these roads, it was decided that the intersection itself would not have any traffic lights, but would be realized in form of an interchange. Unfortunately, the development and realization of this project took place in a time when the influence of noise on people and the quality of life were not of primary concern. Because of that, a number of buildings, both residential and business, are now located in the close proximity of the intersection, suffering high levels of unwanted traffic noise. In order to reduce the noise to a tolerable level, studies have been made to determine the possible course of action. The results of these studies are shown here.

## INTRODUCTION - THE DESCRIPTION OF THE INTERSECTION

The intersection, for which the solution of traffic noise reduction is presented in this paper, represents one of two major intersections in the city of Zagreb where the Marin Drzic Avenue, connecting the northern and the southern part of the city, intersects with the main city transversal, the Slavonska Avenue, stretching from the east to the west. Slavonska Avenue has two traffic lanes in each direction, while Marin Drzic Avenue, stretching from the north to the south, has three traffic lanes in each direction and the bidirectional tramway line located in the centre of the road. As stated in the abstract, the intersection itself is realized in form of an interchange and, therefore, has no traffic lights in order to increase the traffic flow efficiency. The location of the

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intersection and the corresponding roads and buildings that require noise protection is shown in Figure 1.

*Figure 1 – The cloverstack intersection of Slavonska Avenue and Marin Drzic Avenue[1]*

The photograph shown in Figure 1 was taken from a position east of the intersection itself, making the north actually on the right side of the picture, so Slavonska Avenue has a vertical orientation, and the Marin Drzic Avenue the horizontal one. The photograph shows that the interchange has a cloverleaf shape with collector/distributor roads. The exception is the absence of a loop ramp connecting the northern carriageway of Slavonska Avenue and the western carriageway of the Marin Drzic Avenue, which could not be built due to the lack of space caused by close proximity of existing buildings on the north-western side of the intersection. Instead, a flyover ramp was built to substitute for the missing loop ramp, giving this intersection a so-called cloverstack shape.

The distinctiveness of this intersection is that it was constructed and built in the late 1960s and is located within the existing residential zone. However, traffic noise was of no concern in those times and in this geographic region, which is understandable regarding the small number of vehicles present at that time. Given the number of vehicles, a three-level realization of the intersection did not reflect actual traffic requirements, but acted more as a proof of the ability to compete with western civil engineers and architects. However, oversizing the intersection at the time it was constructed was a somewhat visionary move, because now, almost forty years later, the traffic intensity has increased so much that the intersection has almost reached the limit of its traffic flow capacity.

## INPUT DATA

### Permitted vehicle speeds

Permitted vehicle speed on Slavonska Avenue is set to 70 km/h in either direction, 60 km/h on Marin Drzic Avenue and 50 km/h on all collector/distributor roads except on the flyover ramp, where it is set to 40 km/h for safety reasons. The stated values were used in the calculations because they represent the worst permitted case.

Each of the two carriageways of intersecting roads has been declared an independent and separate traffic noise source, having its own set of input parameters, as well as all the collector/distributor roads.

### Number of vehicles

The number of vehicles has been determined from the estimated maximum number of vehicles these roads can handle. From this data the necessary parameters for road traffic noise calculations have been calculated according to RLS90. The obtained values are shown in Table 1.

*Table 1 – Number of vehicles and permitted speed expressed for the intersecting roads*

| Road | Number of vehicles per hour | | Percentage of heavy vehicles [%] | Permitted vehicle speed [km/h] |
|---|---|---|---|---|
| | Day | Night | | |
| Slavonska Avenue - northern carriageway | 1200 | 220 | 20 | 70 |
| Slavonska Avenue - southern carriageway | 1200 | 220 | 20 | 70 |
| Marin Drzic Avenue - eastern carriageway | 600 | 110 | 20 | 60 |
| Marin Drzic Avenue - western carriageway | 600 | 110 | 20 | 60 |
| The flyover ramp | 180 | 33 | 20 | 40 |
| Other collector/ distributor roads | 180 | 33 | 20 | 50 |

**Other corrections**

Since the slope of each individual part of the roads forming the intersection does not exceed 4 %, no additional correction has been used. The quality of the asphalt cover on the roads in question corresponds to ‘smooth asphalt cover’, as stated in DIN, yielding a correction of 0 dB.

**The applied noise control criterion**

The noise control criterion applied for this intersection has been taken from the Regulations on the highest permitted noise levels in working and residential environments (NN 145/04): “Zone 4: The mixed-purpose, mainly business and partly residential zone”.

The maximum permitted outdoor noise level $L_{Aeq}$ in the fore mentioned zone equals 65 dB(A) during the day and 50 dB(A) during the night.

In compliance with HRN U.J6.201 norm, traffic noise level $L_{Aeq}$ in residential spaces with the windows closed must not exceed 45 dB(A) during the day and 35 dB(A) during the night.

## NOISE LEVEL CALCULATIONS

The simulations have yielded the noise levels in steps of 5 dB, from 35 dB(A) upwards. Since the roads of interest are located in the city and a number of residential buildings and family houses are located in their vicinity, the simulations and calculations have been performed for the entire area surrounding the intersection, as well as for the streets located in its proximity.

The possibility of implementing noise protection using the sound barriers has been examined for all buildings and structures within the defined protected zone (the location of a building is defined as an imission point – critical point). The barriers have lengths and heights as demanded by the calculation in order to reduce the noise level at the imission point to the permitted value $L_{Aeq}$ = 50 dB(A) for night time. The three-dimensional computer simulation has been used to make the noise map showing the present condition in the investigated city zone, i.e. without the sound barriers. Based on this simulation, critical imission points (buildings) have been defined in order to calculate the required dimensions of the sound barriers. This calculation has yielded the heights, situations and types of barriers to be used as noise protection elements. Using the data obtained in this manner, three-dimensional simulations have been conducted again in order to verify the data and to determine possible changes in the propagation of noise due to the influence of the noise barriers. The length and the height of noise barriers has been optimized using a LIMA simulation program, with regards to the terrain, the situation of the roads and the height of the buildings at the investigated location.

The altitude at which the noise levels have been calculated has been set to 4 meters (the average height of the first floor of a family house). Given the specific nature of roads passing through an urban zone and the actual heights of buildings located in the vicinity of the intersection, the calculations have also been made for altitudes of 8, 12, 16 and 20 meters above ground level in order to determine the influence of noise barriers on the buildings as imission points throughout their height.

The calculations have established that noise levels in the vicinity of the investigated intersection exceed the maximum permitted values, i.e. 65 dB(A) for day and 50 dB(A) for night period. Therefore, additional noise control measures are to be implemented within this zone.

The results of the 3D simulation for the night period without the noise barriers are shown in Figure 2, and with the noise barriers in Figure 3.

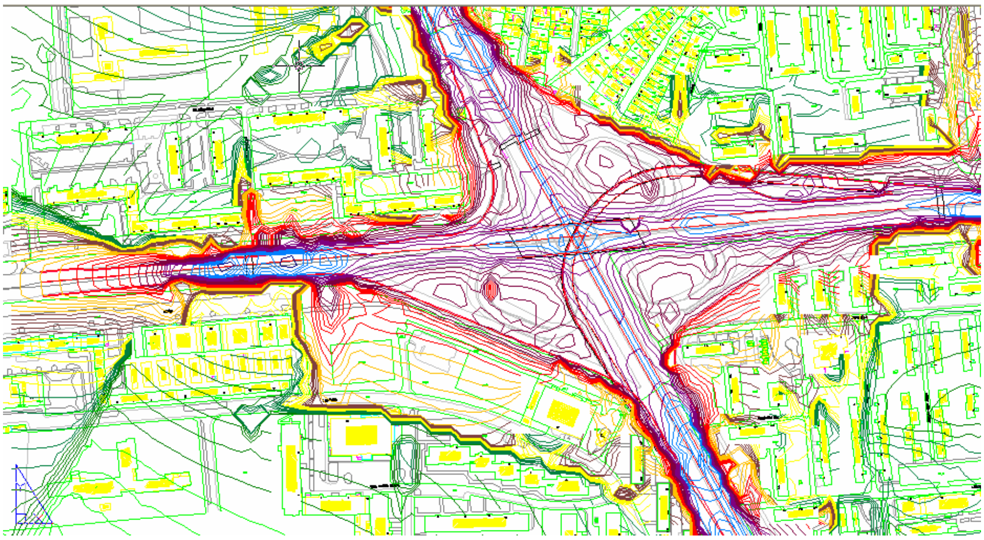

*Figure 2. Simulation results with no noise barriers applied*

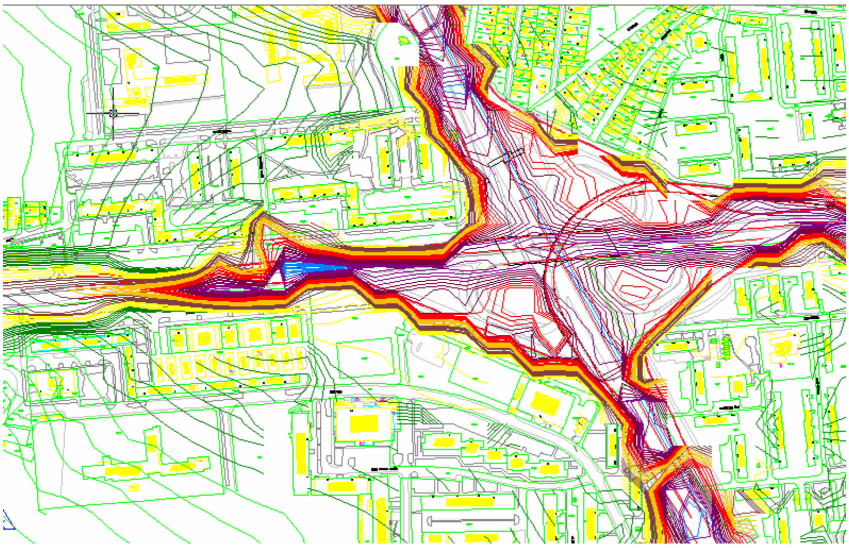

*Figure 3. Simulation results with the noise barriers applied*

## NOISE LEVEL ANALYSIS

In this particular case, the night period has proved to be critical when residential buildings are concerned and was therefore declared significant for proper dimensioning of the required protective elements.

Based on the noise map obtained without the implementation of noise barriers, the calculations have been made for each and every critical building and family house. The calculations display noise levels contributed from each carriageway of both main intersecting roads and/or the collector/distributor roads. After that, the calculations of noise barrier heights, required to lower the noise level to the permitted value, have been conducted for each carriageway and collector/distributor road having a significant influence on the investigated building/family house. The results show that the influence of noise emitted from the farther carriageway of the road, in relation to the building/house, cannot be neglected and that the noise barrier designed for the nearer carriageway cannot successfully lower the level of this noise. Therefore, noise barriers have been designed independently for each of the two carriageways of both main roads. For this reason, noise barriers are to be placed at both the sides of each road and to the middle, between the carriageways of each road. Noise barriers in the Marin Drzic Avenue placed between the carriageways are actually placed between the tramway tracks and each of the two carriageways. This particular solution has been chosen in order to reduce the distance between the noise sources and the barriers, so the desired reduction of noise levels can be achieved using lower noise barriers.

The calculated noise values ranged from 51.9 dB to 71.8 dB for daytime period. As stated before, noise level values in the night time period were more critical and they fell in the range from 44.5 dB to 64.5 dB.

Besides the sound insulation properties of noise barriers, the 3D calculations also considered their absorption characteristics, thus checking for possible unwanted propagation paths of the reflected sound and the increase of noise levels at locations where no problems were initially detected. The results of these calculations show negligible decrease of noise levels due to absorption properties of the barriers, but also show a significant decrease of noise levels at the imission points, i.e. the facades of the protected buildings, thereby achieving the primary goal.

## THE APPLIED NOISE CONTROL MEASURES

The dimensions and the properties of noise barriers, to be used as a mean of noise control, were obtained based on noise levels exceeding the maximum permitted values. The barriers themselves were designed as thin wooden and transparent panels. All applied noise barriers incorporate a sound absorbing element at their base. Since the barriers in the Marin Drzic Avenue are to be constructed on soil, wood has been chosen as the suitable building material for construction of the barriers. The absorbing parts of the barriers situated along the Slavonska Avenue are made of transparent polycarbonate, due to the fact that the bearing elements of such barriers can be fitted easily to the already existing crash barriers. The absorptive part of the barriers bears the transparent polycarbonate part having the insulation characteristics. The thickness of the insulating polycarbonate panel should be at least 8 mm, i.e. the surface mass of such panel must not be smaller than 20 kg/m$^2$. Small distance between the protected buildings and the roads as noise sources resulted in relatively high barriers, so it was decided that curved barriers should be used, since they provide the same effective height having a smaller absolute height than a straight barrier. Further increase in efficiency of these barriers was achieved by adding elliptic absorption elements to the top of the barriers. The data obtained from literature shows that such elements increase the values of sound insulation by 3 dB.

All barrier elements are Croatian products and comply with the HRN EN 1793 group of standards, stipulating the acoustical properties, and to HRN EN 1794 group of standards, stipulating the mechanical properties of noise barriers.

## FINAL RESULTS AND CONCLUSIONS

Although the project dealing with noise control on the intersection of Slavonska Avenue and Marin Drzic Avenue has been completed for some time now, it has not yet been realized. Unfortunately, the total costs represent a big obstacle for the actual realization of this project at this time, so it is very uncertain whether this project will ever come to life. Nevertheless, the most probable appearance of noise barriers to be constructed on this intersection some day in the future was obtained by photo manipulation and is shown in Figure 4.

*Figure 4 – The appearance of noise barriers to be applied as noise control elements*

Civil engineering regulations limit the height of the self-standing noise barriers to 5 meters, which was not enough to protect relatively high buildings located in the close proximity of the intersection. The only possible solution would be to convert the critical parts of the intersection into ground-level tunnels.

Despite the simulation results, the only true measure of validity of this approach to noise control at the given intersection will be the actual noise measurements performed upon the realization of this project.

## REFERENCES

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