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PROTECTION AGAINST NOISE ON A6 HIGHWAY RIJEKA-ZAGREB, KARLOVAC –NOVIGRAD SECTION

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Abstract

Although it is not a member of European Union, The Republic of Croatia has brought the regulation regarding the noise protection which has been harmonized with The European Directive 2002/49/EC. Technical committee within the Croatian Normization Institute has acquired more than a hundred European norms from this area. In spite of that the noise protection in urban regions of Croatia is carried out sporadically. Only in those areas along roads where the noise levels are extremely high and the objections of local residents directed to town authorities are frequently repeated for years. The situation is completely different in case of excessive noise levels of the inhabited areas along highways. Stock companies which manage highways follow the orientation of the Republic of Croatia to take special care of the environment, and, thus, of the noise protection. Approximately 10 years ago intensive road construction started in Croatia and so far 1062 kilometres of highways have been built. The solutions for the noise protection that have been planned in the project documentation, mostly walls, have been carried out. In this paper the procedure of predicting the noise level in the environment in the process of making project documentation has been described for the section of the highway Karlovac-Novigrad. The real situation in the environment regarding the noise caused by traffic was determined by field measurements five years after the section in question had been opened to traffic. The prediction of noise protection on the project level has been commented upon with regard to the present noise condition when the highway is in circulation. It has been pointed out that that the noise protection by walls is only one very important, but not sufficient measure, and that overall solution requires permanent monitoring, establishing the system of condition monitoring, analysis of effectiveness and the possibility of application of other primary and secondary protection measures.

1. INTRODUCTION

Increased urbanization is connected to the increase in the number of vehicles on European roads, as well as in Croatia which does not lag behind. It is especially visible in the multiple increase in motor vehicles on city roads, as well as outside inhabited areas. It is known that, regarding the traffic noise, the road traffic is one of the biggest environmental pollutants in general [1].

According to the Directive 2002/49/EC [2] adopted by the European Commission in 2002 and the Law on Noise Protection [3] proclaimed in Croatia in 2003, continuous

monitoring of environmental conditions regarding the noise pollution as well as noise mapping are prescribed. The objective is to improve the situation in high exposure areas and to protect quiet areas. In these terms, in the process of planning and designing new buildings it is necessary to pay special attention not only to the estimate of their influence on the environment in order to strongly prevent the noise level increase above the permitted values prescribed by the Highest permitted noise level Regulation for places where people work and reside [4], but also to urban development plans for settlements and towns which adopted them and prescribe the highest permitted noise levels with regard to the purpose of the area. Although there are regulatory measures, in practice the noise protection in the Republic of Croatia is generally given less significance than the other segments of environmental protection (energy efficiency, soil and air protection against pollution). It is not the case with the noise protection along newly built highways. They are recently being intensively built and the noise protection of the settlements near these roads is carried out systematically by constructing different types and sorts of noise protection walls.

Planning, designing and implementation of protection are an extremely important but not a sufficient step in the process of improving environmental noise situation. For the insight into the real noise situation and the assessment of the implemented protection measures it is necessary to record the real conditions by field measurements upon opening the highway to the traffic. The opinion of the experts dealing with these issues is that it is optimal to take the situation after five years. The contribution to such approach to solving the noise protection issue is described in the paper.

2. LOCATION DESCRIPTION

Figure 1. Zagreb – Rijeka Highway, Karlovac – Novigrad Section.

Karlovac-Novigrad Section (Figure 1.), 12035 km long, is situated on A6 Highway Rijeka – Zagreb and was opened to traffic on June 11th, 2001. The road in question is a part of European highway communications E65 and E71 (Hungary –Varazdin – Zagreb – Karlovac -

Rijeka). Karlovac - Bosiljevo I Section, 12410 km long, opened to the traffic in June 2005 is also a part of A1 Highway Zagreb – Split which is, at the same time, a part of European highway communication E59 (Austria – Maribor – Zagreb – Karlovac – Split). Karlovac – Novigrad Section of the highway is a part of highway communications leading from Central Europe to the Adriatic Sea, being thus the connection between the north and south, i.e. between Continental and Adriatic Croatia. In 2005 by opening Karlovac – Bosiljevo I Section the already large traffic volume on Karlovac - Novigrad Section was additionally increased. The traffic volume, especially in the summer, during the tourist season, is exceptionally big, twice as bigger as the average annual daily traffic with the significant number of heavy vehicles [6]. That is the reason why the noise levels in close proximity of this road are constantly very high. Since the section monitored in the paper passes mainly very close to the settlements, the problem of environmental pollution by traffic noise is very pronounced.

3. PROTECTION AGAINST NOISE - DESIGNING PHASE

The project of the noise protection of Karlovac-Novigrad Section was made in 1997 as a part of the main project of Rijeka-Zagreb Highway, [7]. The analysis of the existing and the prediction of the future situation of environmental noise due to the construction of the new communication conducted in the project included all the buildings in the about 200-metre-wide corridor on either side of the highway centerline. Project documentation [7] analyzed 5 tested areas. Depending on its characteristics, the testing for an individual area was carried out on one or more measuring points. Within 5 testing areas 11 measuring points were analyzed and the immission noise level was determined.

The calculation of noise emission and immission was carried out according to DIN 18005 Teil 1 [7] separately for day and night. Due to small distances between the highway centerline and the relevant, as a rule, the closest buildings, the calculations of the immission were conducted separately for each roadways of the highway, followed by the superposition. For each roadways the height of 0.5 m above the pavement on line between the outside and inside line [7] was accepted as the roadways emission axis (see Figure 3.).

The calculation of the emission was carried out for the relevant traffic load, permitted speed of 120 km/h and asphalt concrete pavement. Longitudinal gradient bigger than 5%, which according to the German method is relevant for the calculation of noise emission, does not appear in any tested area. The relevant traffic load, the relevant year 2017 and the project period of 20 years have been taken over from the Project of roadway construction structure [7]. Supposed average annual daily traffic (AADT) amounted to 12869 vehicles in both directions, i.e. 6435 for one direction. According to the German method the day and night traffic load was calculated as well as the share of heavy vehicles for the day and night period.

The noise emission on Karlovac – Novigrad Section was determined at two measuring points since the conditions influencing the noise emission do not change. The noise emission value obtained by calculation amounted to 85.9 dB (A) for the day period and 81.3 dB(A) for the night period for measuring points, EMI north and EMI south (Figure 2).

Noise immission was calculated only for buildings closest to the highway and will, thus, be exposed to the highest noise level relevant for the calculation. The supposed height of the immission point for buildings P+1 (ground floor + one floor) was 5 m, and for single-storey buildings 2.5 m above the terrain hill [7].

According to the results given in the project documentation, in 5 areas of the monitored section the noise level is the highest in area 3, therefore, compared to others, the highest protection walls (4.5 m) are planned here. Walls higher than 5 m, cannot, as a rule, be built by usual construction methods with reasonable costs [5]. Due to the stated reasons exactly this area (area 3 from project) was chosen for field measurements. It includes two measuring

points. Three measuring points were chosen initially. The measuring points 3-j-s was left out of the analysis since it turned out that it would be necessary to construct the wall higher than 8 m to obtain the immission noise value lower than or equal to 50 dB(A), as the Regulation prescribes [8]. Noise immission values obtained by calculation are shown in Table 1.

Table 1. Noise immission values obtained by calculation.

Measuring points	Noise immission values according to DIN 18005 Teil 1, L_{Aeq} (dB(A))			
	Without sound protection		With absorbing wall	
	Day	Night	Day	Night
3 - j – 2 (Figure 2.)	69	64	54	49
3 - s – 1 (Figure 2.)	63	58	54	49

According to [8], the zone 4 of the mixed, mostly business purpose zone with apartments, the maximum permitted noise immission level for the day period amounts to 65 dB(A) and for the night period to 50 dB(A). On the basis of the calculated values (Table 1.) for noise protection projects the relevant period is night. The calculation showed that at measuring point 3-s-1 it is necessary to construct a 4.5 m absorbing wall along the south roadway shoulder and on the top of the cut south of the highway centerline (Figure 2.)

According to new Regulation from 2004 [4], the highest permitted noise levels for the monitored areas have not changed and the planned protection would be harmonized with the new regulations.

4. PROTECTION AGAINST NOISE – EXPLOITATION PHASE

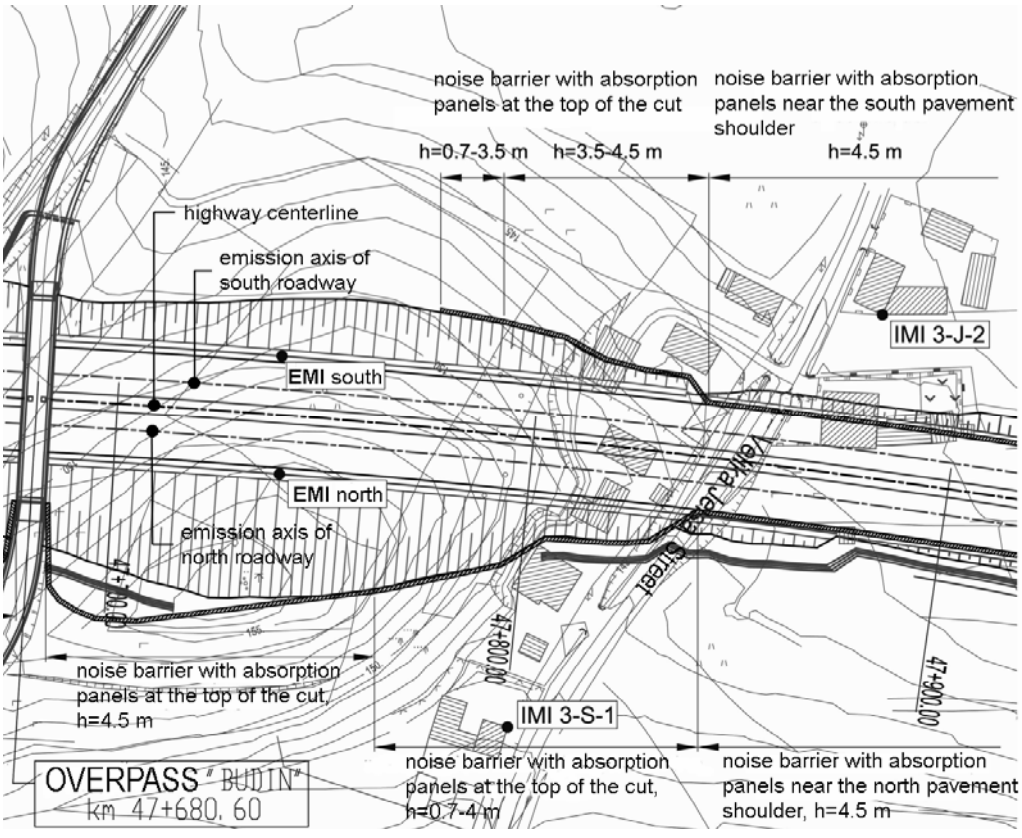

Figure 2. Illustration of measuring points.

In order to determine noise protection situation 5 years after the opening of Karlovac – Novigrad Section to the traffic the field measurement of the noise level was carried out [9] as follows: noise emission (Figure 2.) on places EMI north, on the north roadway and EMI south, on the south roadway. Noise immision measurement was carried out on 3-s-1, house north of the highway centerline on the chainage 47+800.00, in 3.53 m high cut and at the distance of 61 m from the north roadway axis and on 3-j-2, house south of the highway on the chainage 47+878.00, in 3.53 m high cut and fill at the distance of 33 m from the south roadway axis.

The traffic volume was measured at one measuring points. There is no exit or entrance to the highway between the intersections Karlovac and Novigrad and it does not change [9].

4. 1. Noise Level Measurement

Four short-term 20-minute noise level measurements were carried out in favourable meteorological circumstances, at temperatures of 25°C,on the mentioned locations, two per night and two per day period. The measurements in the day period were, carried out in the period between 15.00 and 17.00, and in the night period between 22.00 and 24.00. According to [3] 24 hour period was divided into three parts: the day from 06.00 to 20.00, the evening from 20.00 to 22.00 and the night period from 22.00 to 06.00. According to [4] the highest permitted values for the period day, evening and night were prescribed. The highest permitted values prescribed for the day were applied for the night period as well. Since the values obtained in the period day are relevant (less favourable), measurements in the evening period were not even organized.

Precise sound level meter was positioned on the aluminium telescope stand (tripod) at 1.2 m height from the ground. In the case of measurement at measuring points EMI north and EMI south the precise sound level meter was 7.5 m far from the motorway axis. The noise emission was measured for each roadway of the highway separately. Medium values of the equivalent noise emission level measurements are shown in Table 2.

Table 2. Results of noise emission measurement.

Emission noise level $L_{A,eq}$ in dB(A), t=20 minutes			
EMI north (Figure2.)		EMI sought (Figure2.)	
Day	Night	Day	Night
77.5	76.0	76.9	76.1

Noise immission (see Figure 2.) was measured at the distance of maximum 3 m from the buildings, measuring points 3-s-1 and 4 – 3-j-2. Medium values of the equivalent noise imission level were shown in Table 3.

Table 3. Results of noise immission measurements

Immission noise level $L_{A,eq}$ in dB(A), t=20 minutes			
3 - s - 1 (Figure2.)		3 - j - 2 (Figure2.)	
Day	Night	Day	Night
51.1	52.2	52.2	50.0

4. 2. Traffic Measurement

Traffic measurement was carried out by monitoring the traffic load by video-camera for the duration of 60 minutes. Vehicles were divided into 3 groups: passenger cars, light and heavy (heavy trailer trucks, tractors and buses) trucks. The results are shown in Figure 3.

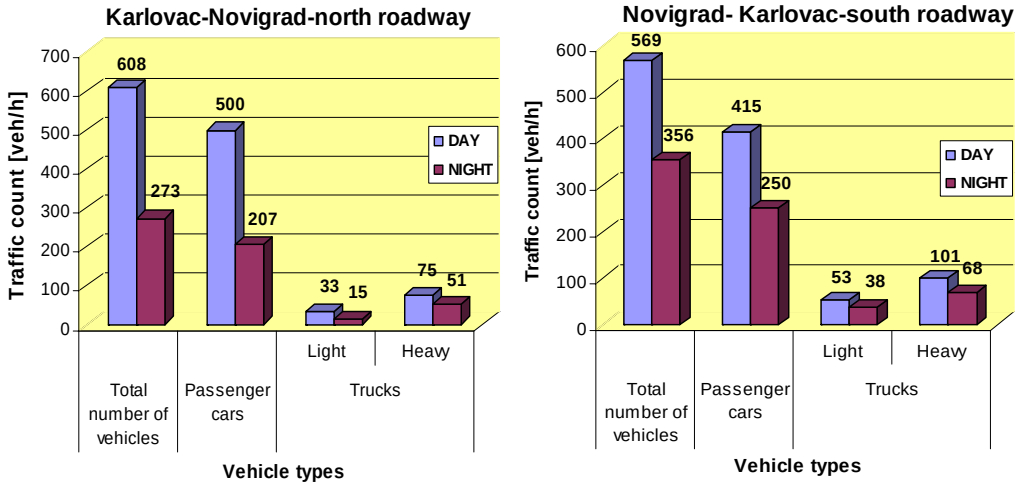

Figure 3. Traffic measurement

4.3. Noise Situation Assessment

Although Karlovac - Novigrad Section, monitored in the project, was divided into 5 areas for which the noise situation was predicted, the analysis of the conditions in the field was carried out only for the area 3 since, according to the project documentation, noise situation for this area was the least favorable. The field measurements showed that the calculation resulted in the emission noise level (EMI north and EMI south) stated in the project [7], in comparison to the field measurements higher than 9 dB(A) for the day and 5 dB(A) for the night period. The real traffic load is c 27% higher of the one predicted by the project.

On the locations where measuring points 3-s-1 and 3-j-2 were situated, noise protection absorbing walls planned by the project were constructed. The calculated immission noise levels at both measurement places amounted to 49 dB(A). The levels measured in the field were higher than the ones obtained by calculation. At the measuring ppoint 3-s-1 for the night period the imission noise level was higher by 2.2 dB(A), and at measurement place 3-j-2 by 1.1 dB(A) than the highest permitted values of 50 dB(A) prescribed by the Regulation [4,8].

It is not surprising that noise level values measured in the field are higher than those obtained on the project level by calculation. The number of passenger vehicles for day taken in the project is 386 veh./h and 458 veh./h were measured. In the night period the project planned 90 veh./h and 229 veh./h were measured. The share of heavy vehicles according to the project was 25% for day and 45% for night while field measurements showed on average 30% for day and 38% for night. The traffic load is, already in 2005, bigger than that planned by the project for the year 2017. According to [6] the average annual daily traffic (AADT) in 2005 amounted to 17585 vehicles. It should be stressed that in summer months, from June to October, the situation on this section is much more inconvenient. In this period traffic volume is doubled and amounts to 35378 vehicles. The environmental noise situation reached in the summer of 2006, showed the necessity of taking additional measures in terms of noise protection. The reason is generally bigger amount of vehicles than the one planned on the level of the project, especially in summer. Traffic load data describing the average state in one year were used in the project. The planned traffic load is different from the real one, therefore it is clear that the existing protection is not sufficient. However, in the analysis of the situation at this location another question arises. Should the information used for noise protection be based on the average annual daily traffic or average summer daily traffic? Can more inconvenient noise situation during at least three summer months be neglected all the more so because the measured noise levels are higher than those permitted by the Regulation [8]? The next question is which measures to take considering that the executed protection planned until

2017 is insufficient already in 2006? One should also bear in mind the fact that in more developed European countries, Croatia not lagging behind, road traffic is increasing, therefore, environmental noise conditions will probably worsen.

5. TRAFFIC NOISE MITIGATION MEASURES IN THE HIGHWAY ENVIRONMENT

In generally, measures aimed at preventing noise propagation are included into the planned space management while the protection at immission locations is carried out by positioning noise protection barriers or improving sound insulation of buildings. The construction of noise protection walls in Croatia is the only measure applied for the protection noise along highways. Although the construction of noise protection walls decreases the noise level very much, the example described in the paper and others [10] show that, due to the configuration of the terrain where the road passes, the desired effect is not obtained. One should not neglect the fact that, by planned construction of buildings at sufficient distance from the roads as well as by the correct arrangement of the rooms in the building and the application of sound insulation, noise levels could be lower up to 10 dB(A). This measure can hardly or almost never be applied to already build roads and buildings. Sound insulation of buildings can be easily applied all the time, but it comes within the competence of the owner. This measure, in principle, is not applied since the owners themselves should finance such protection. In case of disturbances caused by increased noise levels, local residents act in an organized way and write petitions to highway management or local administrations. In areas where, due to field conditions, the protection by noise absorbing walls is not efficient or very high walls should be constructed, the possibility of protection by sound insulation of the building should be considered. Comparative analysis between constructing noise protection walls and sound insulation of windows and doors of the building showed that protection by sound insulation saves even up to 50% of financial resources and up to 30% of the time necessary for construction compared to the construction of noise protection walls with the same efficiency of the applied protection measure [10].

In the attempt to achieve satisfactory noise level decrease along highway sections situated in the vicinity of residential areas, in developed European countries measures which mitigate noise at source, such as speed limit especially of heavy vehicles, are, frequently applied, and the decrease in traffic load less frequently. Also, efforts are made to influence the drivers' consciousness, therefore, warnings are put which indicate the change of traffic conditions (speed, acceleration, deceleration, stopping and starting) with the aim to reduce the noise level in the environment. Similar solutions can be applied to the monitored section of the highway. The application of other protection measures is not only within the competence of the management but implies including all participants from state authorities and experts to highway users. Economic protection measures accompanied by regulations such as fees for vehicles which noise level is higher than permitted etc., setting up funds which would be used for the execution of noise protection measures as well as research and development are limited even in developed European countries [11]. Noise mitigation at source can be achieved by affecting the structure of the vehicle as well as by applying quieter pavements. A big improvement with regard to vehicle noise reduction was made by adopting European norms, accepted by Croatia as well, which go in the direction of technological improvement of vehicle. Research carried out in Italy, the Netherlands and Finland with less noisy road surface, porous asphalt of different composition and execution showed that the expected noise reduction compared to the asphalt concrete is 3 to 5 dB(A) [11]. Croatia does not have experience with the application of porous asphalt and experts frequently point out that we do not possess technology which would allow their application.

6. CONCLUSION

In the designing phase it has been planned that noise protection will be satisfactory in the project period of 20 years. Although the measurements were carried out in less favorable part of the year, summer, when noise levels are higher than in the rest of the year, it should be said that already after 5 years upon opening the highway to the traffic, the noise levels are higher than those planned for the year 2017.

It is worrying that the obtained equivalent noise level values for the night period in the vicinity of buildings are higher than the highest permitted levels prescribed by [4]. In spite of the limited range measurement it still suggests the potential further development of the situation. Therefore, a systematic analysis is necessary within the framework of the whole programme of testing in order to take adequate measures of local residents' protection against exposure to excessive noise levels in due time.

The noise protection is a permanent process which starts with noise protection planning in the phase of making project, followed by the implementation of planned protection and, finally, by monitoring field measurements at defined intervals. The final objective of the member states of the European Union, as well as of Croatia, is the increase in the quality of living of people who work and live near the roads as well as the protection of quiet areas. Public limited company "Rijeka – Zagreb Highway" Plc. which manages the highway Rijeka – Zagreb follows these objectives. One of the principal objectives which is a result of the basic guidelines of the Company under the motto "safety, ecology and helpfulness" is environment management with sustainable development policy, and, within that, the protection of local residents from excessive noise levels [12]. This problem was recognized as a priority and is thus solved through the programme of construction of different types of noise protection walls. Also, the Company already today considers additional protection measures on the monitored location. They include measures of noise mitigation at source in order to reduce noise pollution and improve environmental conditions, because the 4.5 noise protection absorbing walls, which have already been placed, are not sufficient.

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