



INFLUENCE OF DIFFERENT PAVEMENT SURFACE ON NOISE LEVELS IN PASSENGER CAR

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Abstract

Noise measurements in a vehicle with the purpose of determining riding comfort have been neglected and are rarely done, while considerable attention was paid to the state of noise next to a road in the sense of determining the noise levels in the area through which the road passes, and finding solutions for their reduction, if the measured noise levels were above the allowed ones. The mentioned facts stimulated a research with the goal of determining the noise levels in a vehicle in relation to different types of the pavement structure.

Within reconstruction of pavements on the A3 (E70) motorway, rehabilitation of the Ilova bridge was carried out, where the existing asphalt pavement structure was replaced by the concrete one, while the pavement before and after the bridge was reconstructed with a new asphalt layer. Exactly due to different types of pavement, that section of the motorway was selected as the test polygon for the planned research. Besides measuring noise in a test vehicle, along with its movement speed, measuring of the pavement evenness was done on the pavement, expressed as the IRI parameter (International Roughness Index), which represents a usual datum about the state of the pavement that road authorities regularly collect. On the basis of the collected measurements data, the paper presents the relationship between the noise levels in the test vehicle, its movement speed and pavement evenness.

Keywords: asphalt pavement, concrete pavement, noise in the vehicle, evenness

1 Introduction

In the last 10 years approximately, in the Republic of Croatia, considerable financial funds were invested in reconstruction and development of traffic infrastructure. With application of the modern technological and ecological solutions, over a thousand kilometers of national and other roads were built and reconstructed, by which Croatia, as a tourist oriented country, became much closer (shorter travelling time) to the European market as a desirable tourist destination [1]. At the same time, due also to its geographic position, Croatia was transformed into a desirable and safe transit corridor connecting Western Europe with the countries of eastern and southern Europe and Near East.

A modern and quality road network is one of the basic preconditions for economic development of every country, and one of the indicators of quality of the built road is certainly riding comfort. Among other vehicle characteristics, riding comfort is also affected by characteristics of the pavement and quality of its execution. Exactly for that reason, this paper will consider the effect of different types of pavements (asphalt and concrete one) on riding comfort through measurement of the noise level in the test vehicle and measurement of pavement evenness (IRI_{10}) on the selected section of the A3 (E70) motorway. There are not many roads suitable for testing and comparison of concrete and asphalt pavements in the Republic of Croatia, since asphalt prevails on most of the roads, while concrete pavement is rarely applied, i.e. it is

represented in the total road network only with 0.3%. Concrete pavement is mostly applied in tunnels, roundabouts, bus stations, toll stations, gas stations, and execution and reconstruction of the pavement of bridges.

2 Description of location

As it was already mentioned, measurements of the noise level in the vehicle and pavement evenness were carried out on the A3 (E70) motorway on the concrete pavement of the Ilova bridge, and on the asphalt pavement before and after the bridge. Ilova bridge is 55m long and is an integral part of the Ivanja Reka - Lipovljani section of the A3 motorway, which was put into operation in 1980 (Figure 1). Construction of the whole A3 motorway was finished in June 2006, by which this motorway became the first one in Croatia that was built completely, in the length of 305km, from the border with Slovenia to the border with Serbia. The A3 motorway is a part of the Pan-European corridor 10 which connects Western Europe with Southern Europe (Greece), Eastern Europe (Bulgaria) and Near East (Turkey), and it is mostly loaded with heavy truck traffic among all our roads. On the A3 motorway, there are many bridges, viaducts, overpasses and other traffic structures, but, due to the plain terrain, there are no tunnels. During longtime exploitation, several overpasses and smaller bridges were so deteriorated that their whole span structure had to be replaced. Besides, it was necessary to carry out expensive and extensive works of extraordinary maintenance, i.e. replace the complete wearing course of the pavement and almost 30 percent of the overall intermediate/binder course [2]. Reconstruction of traffic structures and drainage was also carried out, as well as of the equipment and the traffic warning systems.



Figure 1 Location Ilova bridge

The mentioned bridge was reconstructed in 2004 (northern pavement) and in 2007 (southern pavement), whereby the existing asphalt pavement was replaced by the new, concrete one (Figure 2). Reconstruction was done in such a way that the asphalt layer of the pavement was first milled, and then the deteriorated concrete layer of the base structure was removed hydrodynamically under 2500 bar pressure.



Figure 2 Presentation of works on concrete pavement on Ilova Bridge [3]

On the clean surface of hydrodemolished pavement, the fabric reinforcement Q 283 was laid, and special polymer-modified micro-reinforced concrete c 35/45 was installed, with the thickness of 10–16 cm [4]. Installation of the concrete layer was carried out by the vibratory board which does not have the performances of the device for installation of concrete pavement, so that the evenness of the driving surface was of unacceptable IRI index values. Therefore, leveling of the driving surface of pavement was approached, by grinding and granulating to the acceptable evenness from the aspect of safety [4]. The asphalt-concrete wearing course before and after the bridge was also replaced (after milling) with a new layer of Split Mastic Asphalt (SMA, 16mm). Unlike the concrete pavement, asphalt layers before and after the bridge were installed by a paver.

3 Descripton of preformed tests

Evenness of the pavement is described by the IRI - *International Roughness Index* parameter, whereby it describes the reaction of the vehicle to unevenness on the driving surface, and is suitable for evaluation of the total road state. A lower value of the IRI parameter designates a more comfortable ride, and thereby also a “more even” pavement. Beside riding comfort and safety of traffic, pavement evenness also affects durability of the pavement structure and the very vehicles, and it is one of the key parameters in road management. The IRI parameter is most often applied for determining of longitudinal evenness of flexible pavements, and less in case of rigid and semi-rigid pavements [5]. According to the classification by ten European countries, including Croatia, the IRI parameter is divided in 5 classes, and its basic length is 100m (Table 1) [5]. The required value of the evenness index on the wearing asphalt course of a newly-executed pavement structure of motorways according to the technical conditions in Croatia [6] is 1.0m/km. For reconstructed asphalt pavements, the technical conditions [7] are somewhat more lenient and they require evenness of 1.5m/km. There are no technical regulations in Croatia for the concrete pavement requiring adequate evenness.

Table 1 IRI index class and values (m/km) [5]

Classification	Very Good	Good	Fair	Poor	Very Poor
IRI index	0 to 1	1 to 2	2 to 3	3 to 4	4 to 5
IRI (mm/m) motorways and state roads	0.0 – 1.1	1.1 – 1.9	1.9 – 2.6	2.6 – 3.2	3.2 – 3.7
IRI (mm/m) other roads	0.0 – 1.2	1.2 – 2.5	2.5 – 3.7	3.7 – 4.9	4.9 – 6.1

Measuring of evenness on Ilova Bridge, and on the pavement before and after the bridge was carried out by an inertial profilograph type Laserprof, made by Greenwood Engineering. Due to the length of the bridge of 55m, instead of the standard 100m, the basic length for determining the IRI parameter was 10m.

Noise level measuring with the goal of determining riding comfort was performed in the passenger car OPEL Vectra 1.8 16V comfort, with the mileage of 130,000km (regularly maintained on every 15,000km) and equipped with Michelin Energy summer tyres size 195/65/15. The measurements of noise levels were performed in the driver's cab at the co-driver's place by means of the device Bruel & Kjaer Hand-held Analyzer Type 2270, at different movement speeds of the vehicle, from 80 to 130km/h. The test section was only on the northern pavement of the motorway, on the right-hand traffic lane, which was secured by traffic warning systems for the needs of measuring in the length of 600m before and 300m after the bridge, so that the vehicle could move along it without being disturbed (Figure 3).



Figure 3 Test section on A3 motorway

4 Results of measurement of pavement evenness and of noise level in vehicle

The average values of the IRI_{10} parameter on the test section measured by inertial profilograph amounted to:

- before the bridge (asphalt pavement): $IRI_{10} = 0.91$ [m/km],
- on the bridge (concrete pavement): $IRI_{10} = 4.36$ [m/km],
- after the bridge (asphalt pavement): $IRI_{10} = 1.03$ [m/km].

When the obtained average values of the IRI parameter are classified according to the classes from Table 1, it is evident that those on the asphalt pavement are within the values prescribed by regulations for motorways, while those on the concrete pavement are considerably above the given criterion for motorways. Also, it can be said that the evaluation of evenness of the asphalt pavement before and after the bridge is very good, while the evaluation of evenness for the concrete pavement is worse than very poor. Very poor evenness of the concrete pavement was also reflected on the measured noise levels in the vehicle, and thereby on riding comfort too. Measuring of noise in the vehicle was recorded in the time interval of 8 seconds (Figure 4), from which 1.5 and 2.5 seconds were necessary for the vehicle to cross the bridge, depending on the speed of movement. The results of noise measurement at different speeds

of vehicle movement from 80 to 130 km/h are presented in Figure 4 in six different diagrams. In diagrams (Figure 4), short time intervals (from 0.2 - 0.3 s) with the increased noise level can clearly be noticed. They represent passage of the vehicle over the expansion joint. Somewhat higher noise levels in the vehicle can also be noticed during driving on the concrete pavement. Somewhat higher noise levels in the vehicle can also be noticed during driving on the concrete pavement. The difference between the time of impact against the first and the second expansion joint served for control of the test vehicle speed of movement.

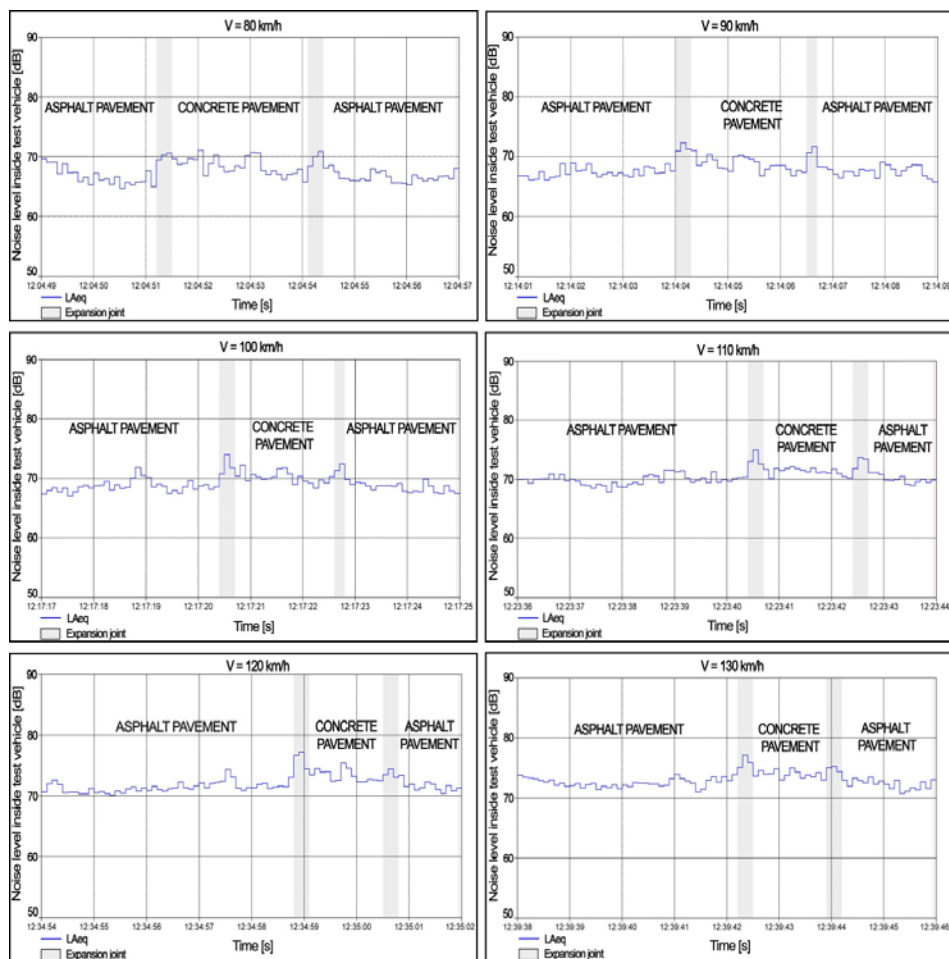


Figure 4 Results of noise level measurement in vehicle during different movement speeds, from 80 to 130 km/h

Besides a detailed presentation of the noise levels inside test vehicle with diagrams, Figure 5 shows the relationship between average values of the equivalent (LAeq) noise level in the vehicle depending on the vehicle movement speed, different type of pavement and passage of the vehicle over expansion joints. It is evident from Figure 5 that noise levels inside the vehicle, while driving on the concrete pavement, are by 1.3 to 1.9 dB higher than noise levels while driving on the asphalt pavement, depending on speed. When the vehicle comes across the first expansion joint (transition from the asphalt to the concrete pavement), the noise level is increased by 3.3–4.8 dB, while it increases by 2.2 to 3.7 dB in comparison to the asphalt pavement at the moment of coming across the second expansion joint (Figure 5).

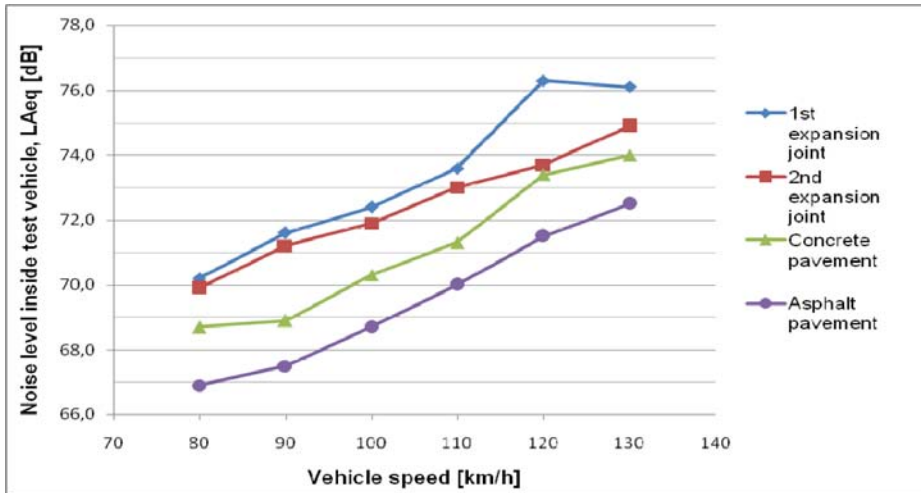


Figure 5 Average noise levels values (LAeq) for different vehicle speed on asphalt and concrete pavement, and over expansion joints

5 Conclusions

The research showed that, unevenness of the concrete pavement and poorly executed expansion joints result in increased noise levels inside the vehicle. The basic reason for the poorly (unevenly) executed concrete pavement of the Ilova Bridge lies in application of an inadequate technology (vibrating board) for execution of the final layer of the concrete pavement, so that even additional works on the pavement could not have reduced the initial poor execution. Application of an inadequate technology is evidently the consequence of insufficient experience in execution of concrete pavements on roads, since, in Croatia, they are mostly applied at places where vehicles stay for a longer or shorter period of time (e.g. toll stations), where evenness is not so important. Except for increased noise levels, unevenness of the pavement causes higher dynamic loads on vehicles [8], and all that leads to reduced riding comfort and higher maintenance costs for the vehicle and for the road. Positive experience from Austria indicates a need of laying asphalt layers of the pavement in the full thickness on the uneven concrete slab, so that evenness of the driving surface would be equalized along the road, and the effect of slab rigidity during use of the road would be smaller [9]. The execution price of such a pavement structure on road infrastructure structures would be annulled with the time of road using through reduced costs of road maintenance and lower operative expenses of road users. The results of measurements carried out, can certainly be of use in future selection of the pavement structure and the technology of execution on road infrastructure structures, and show that particular care should be dedicated to correct execution of transition devices, all with the goal of safer and more comfortable travelling.

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