

## CROATIAN EXPERIENCE IN ROAD TRAFFIC NOISE MANAGEMENT - CONCRETE NOISE BARRIERS

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### *Abstract*

The paper gives an overview of concrete noise barrier application in several EU countries and in Croatia. It describes a process of introducing different noise protection solutions on Croatian market in the phase of intensive motorway construction in recent years. Namely, an extensive motorway network has been constructed in Croatia in the last 10 years. Following the process of motorway construction, noise protection walls have also been erected. Usage of different building materials and installation processes as well as variations in building expenditures has led to a comparative analysis of several types of noise protection solutions (expanded clay, wood fibre) including a new eco-innovative product RUCONBAR, which incorporates rubber granules from recycled waste tyres to form a porous noise absorptive layer.

**Keywords:** road traffic noise, concrete noise protection wall, recycled rubber

## 1. INTRODUCTION

Noise is one of the most pervasive forms of environmental pollution: it affects our lives at home, work and play, deteriorating our health, causing fatigue and reduced work capacity and interfering with communication, concentration, relaxation and sleep. While noise emanates from many different sources, traffic noise is the most difficult to avoid in society today. Although various measures can be implemented to control and reduce traffic noise (application of "quiet" vehicles, driving speed limitation, regular maintenance of pavement surface, traffic management, etc.), most common solution for the traffic noise problem is the construction of noise protection walls, made from various materials.

Both pressures of people's demands for quieter environments and the growing traffic noise levels result in the increase of the scale of noise barriers used to protect communities. This puts pressure on designers to improve their design and effectiveness. As the most common choice for noise protection, noise barriers concepts continue to strive for innovative and visually acceptable solutions, especially for urban areas.

## 2. CONCRETE NOISE BARRIERS FOR ROAD TRAFFIC NOISE MANAGEMENT

The most common way of dealing with excessive traffic noise levels is the construction of noise barriers between the noise source and the protected area. Nowadays, noise barriers are usually made out of concrete, wood or steel. Due to the strict market conditions and demands for durability and static stability, concrete noise barriers are frequently used across Europe.

Sound absorptive concrete noise barriers incorporate a porous layer that absorbs noise. This layer is usually made out of concrete with wood fibres or small lightweight cementaceous spheres as the aggregate [1]. Sound absorptive layer is supported by bearing layer made from reinforced concrete that provides structural integrity and prevents sound passing through the barrier. In order to provide the maximum sound absorption, the surface of the barrier is usually profiled (Figure 1).



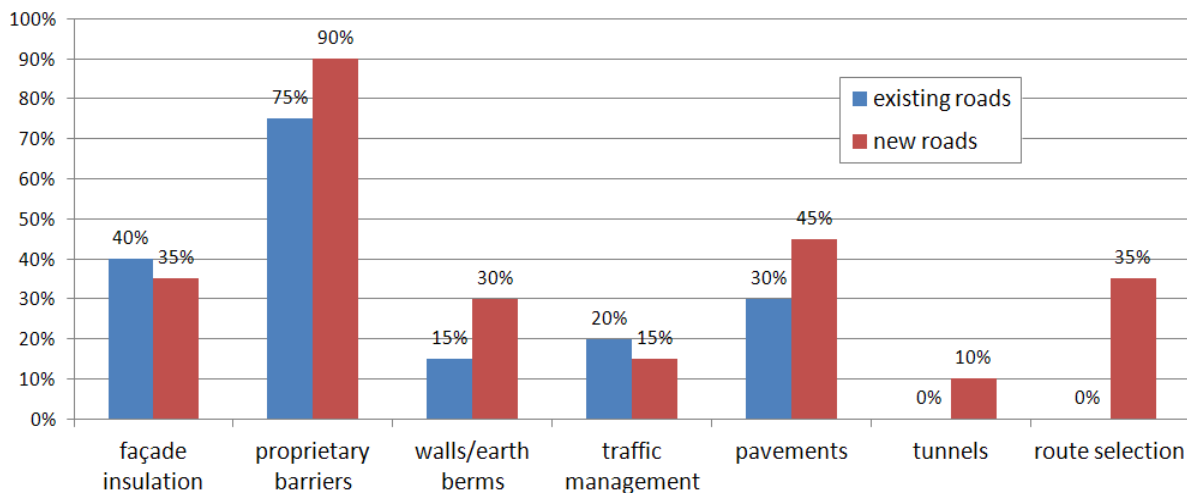
**Figure 1.** Profiled surface of sound absorbing concrete noise barrier

In general, concrete noise barriers have many benefits: they are durable, with a life span of at least 40 years, require minimal maintenance and provide low whole life costs. They are also flexible in design and as such can provide elements of architectural interest, which is very important in noise protection design for urban areas.

Another positive aspect of concrete noise barriers, along with their durability and stability, is their price, which is up to 5% lower than the price of wood barriers, and up to 10% lower than the price of aluminium barriers [2].

## 2.1. Road traffic noise management in EU

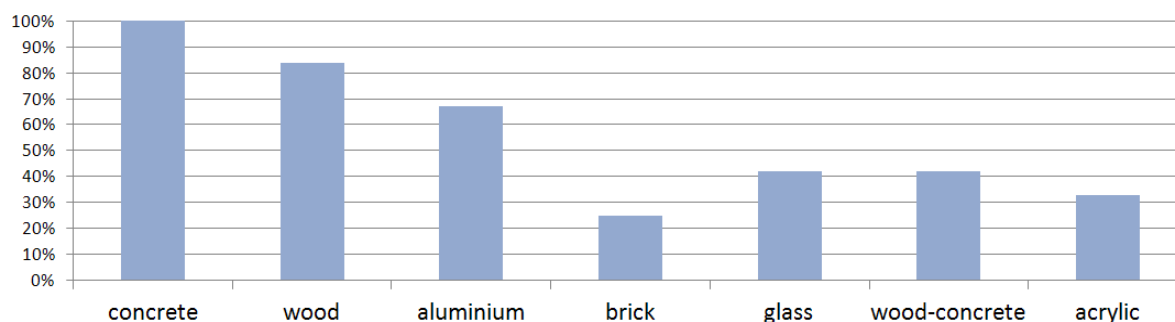
Throughout Europe, noise is an important factor to be considered when it comes to developing, upgrading, and maintaining national road networks. According to the data collected by The Conference of European Directors of Roads (CEDR) via survey on how noise issues are treated in national road administrations around Europe [3], dominating noise mitigation measures on European road networks are proprietary barriers (Figure 2). These noise barriers are predominant measures used to address noise issues on the existing as well as new roads, accounting for up to 90% of all noise mitigation measures.



**Figure 2.** Types of noise mitigation measures in Europe [3]

The results of the same survey showed a wide range of materials that are currently available for the construction of noise barriers, such as concrete, wood, aluminium, brick, glass, wood-concrete, and acrylic (Figure 3). However, the market is dominated by three prominent noise barrier materials: concrete, wood, and aluminium. Additionally, the survey results show that concrete noise

barriers are a common solution for the road traffic noise problem across Europe [3].

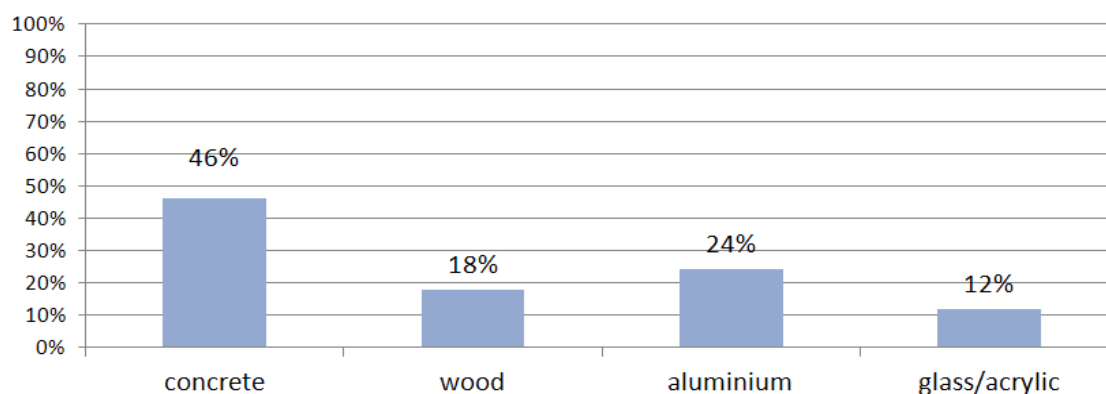


**Figure 3.** The composition of noise barriers and percentage of CEDR member states using that barrier type [3]

## 2.2. Introduction of concrete noise barriers in Croatia

Predominant noise mitigation measures on new, as well as existing roads in Croatia are noise barriers. Until the end of 2007, 158 000 m<sup>2</sup> of noise barriers were constructed on new highways [4], comprising wood, aluminium, and glass or acrylic. Construction elements for these barriers were mainly imported, since their production technology was undeveloped.

During 2006, researchers from the Faculty of Civil Engineering, University of Zagreb, together with experts from two Croatian companies that had the technology for the production of precast concrete construction elements, introduced the sound absorbing concrete noise barriers to the local market. These noise barriers had a porous layer made out of concrete with expanded clay as the aggregate. Soon they became the common solution for road traffic noise problems in Croatia; from 2007 until 2010, sound absorptive concrete noise barriers that were entirely made by local companies and with mainly local materials have taken over the local market (Figure 4).



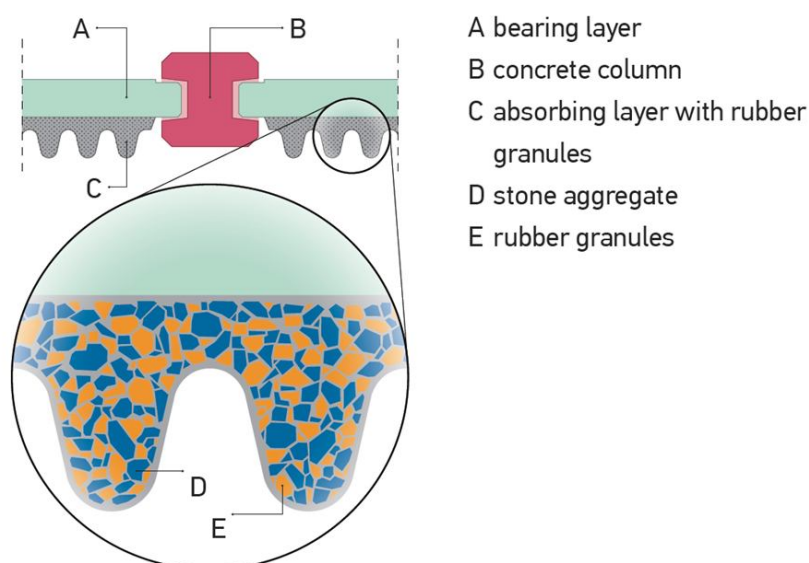
**Figure 4.** Types of noise barriers in Croatia built from 2007 to 2010

Planned further investments in transport infrastructure in Croatia should result in 750 km of new roads, as well as 404 km of modern railways [4]. According to the provided data, the need for effective noise barriers will surely rise, and the noise absorbing concrete barriers will certainly keep their place on the market.

### 3. COMPARATIVE ANALYSIS OF CONCRETE NOISE BARRIERS

Common materials used today in the construction of noise absorbing layer are wood fibres and expanded clay granules. Using these materials is contrary to sustainable development as their production causes significant changes in the ecosystem. Namely, the production of wood fibre requires severe deforestation, and manufacturing expanded clay also causes significant depletion of natural resources irreversibly leaving stripped and devastated environment.

Porous lightweight concrete absorption layer that was introduced to Croatian market in 2006 was comprised using the expanded clay granules, so researchers from the Faculty of Civil Engineering, University of Zagreb, continued research aimed at finding alternative materials for absorption layer of concrete noise barriers. In order to replace natural resources, whose usage degrades the environment and natural balance, a new approach for forming the absorbing layer was developed: a new product named RUCONBAR (Rubberised Concrete Noise Barriers), which incorporates rubber granules from recycled waste tyres to form a porous sound absorptive layer (Figure 5).



**Figure 5. RUCONBAR's elements**

Hereinafter results of noise absorption properties tests of this new product are given, as well as comparison between new and existing products on the market in terms of acoustic performance and the results of LCA.

### 3.1. Sound absorption

The most important property of the described noise protection barriers is the ability of noise absorption. Acoustical absorption is the property of any material that changes the energy of sound waves into another form. Due to the fact that RUCONBAR contains untested material in its absorbing layer, the testing of absorbing properties was conducted in order to determine its sound absorbing behaviour. Sound absorption tests of noise protection barriers with absorbing layer made of expanded clay (LIADUR) and wood-concrete (FASSETON) was also conducted, on samples with similar absorbing surface cross sections and with the thickness of absorbing layer of 10 cm (Table 1) [5].

**Table 1. Single-number rating of sound absorption [6]**

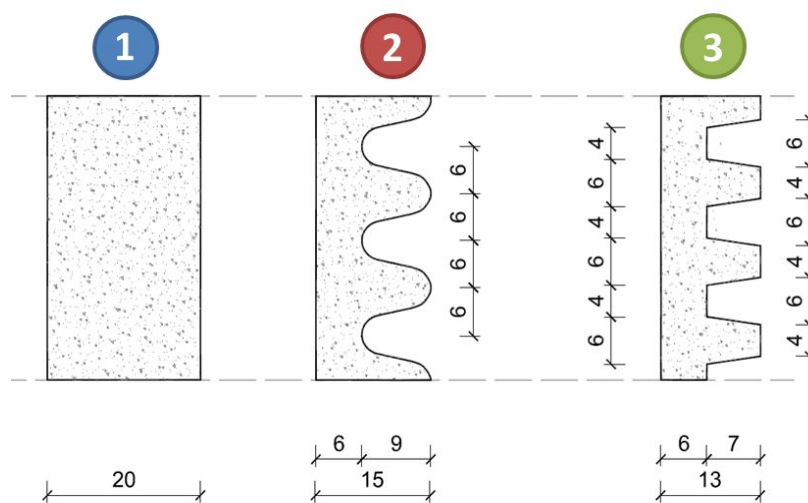
Product	$DL_{\alpha}$ [dB]	Sound absorption class
Wood-concrete barrier	7	A2
Expanded clay barrier	4,4	A2
Recycled rubber granules	6	A2

According to the measurement results, RUCONBAR noise protection barrier has been listed under A2 class of sound absorption, based on the sound absorption value ( $DL_{\alpha}$ ) of 6 dB. Conducted testing indicate satisfying absorption properties and the possibility of their improvement through further development with the goal of reaching class A3 of sound absorption. The competitive products can achieve higher classes of sound absorption, which greatly depends on the cross section of the absorption surface, as shown in Table 2.

**Table 2. Single-number rating of sound absorption for different cross sections**

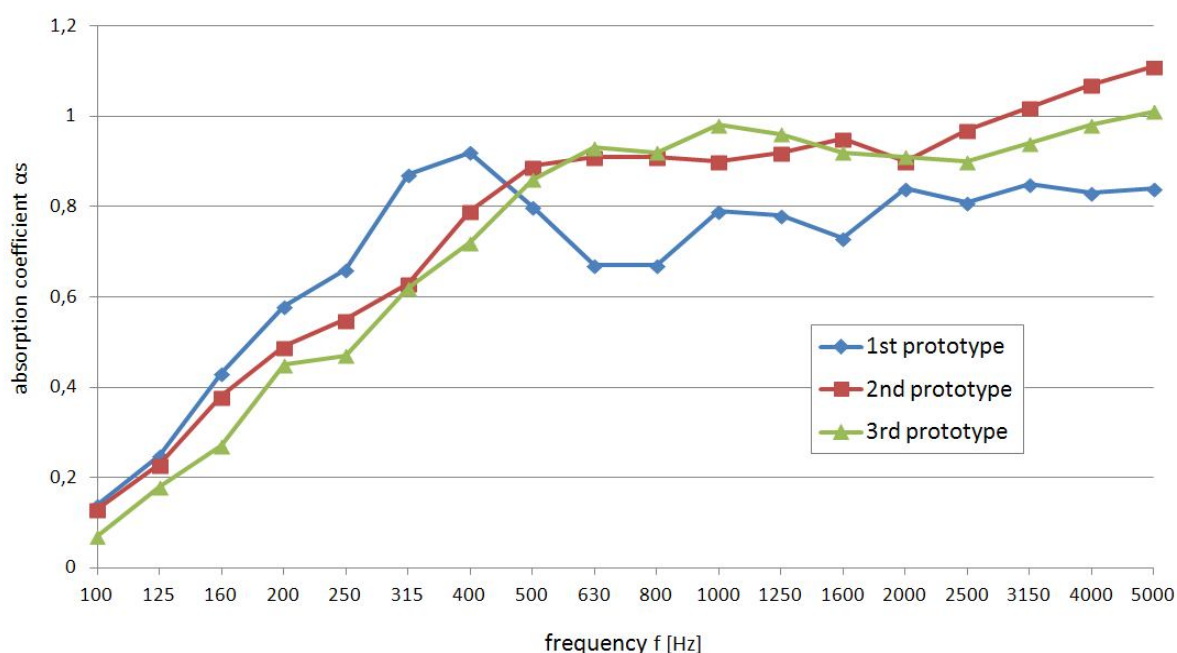
Product	Shape of surface	Absorbing layer [cm]	$DL_{\alpha}$ [dB]	Sound absorption class
<b>Wood-concrete barrier</b>	block	9	8 – 11	A3
	low wave	11	8 – 11	A3
	high wave	12	> 11	A4
<b>Expanded clay barrier</b>	flat	15	4 – 8	A2
	trapezoidal	11	8 – 11	A3
	high wave	13	> 10	A3

In order to achieve higher classes of sound absorption, different optimization prototypes of RUCONBAR were also designed and tested. Optimization prototypes differed in thickness and shape of their absorbing layer: flat, undulating (high wave), and trapezoidal surface (Figure 6).



**Figure 6.** Cross sections of optimization prototypes' absorbing layer

Results of these tests, namely the sound absorption coefficients  $\alpha_s$  (used to express sound absorption capability of tested materials by turning energy of the sound wave into heat), single-number rating of sound absorption  $DL_\alpha$ , and class of absorptive performance for each optimization prototype are shown in Figure 7 and Table 3 [7].



**Figure 7.** Sound absorption coefficients for different optimization prototypes

According to the measurement results, RUCONBAR noise protection barrier has been listed under A2 and A3 class of sound absorption, depending on the shape of the absorbing layer's surface. The highest single-number rating of sound absorption  $DL_\alpha$  was achieved with second optimisation prototype - high wave (Table 3).

**Table 3. Single-number rating of sound absorption for different cross sections of RUCONBAR**

Product	Shape of surface	Absorbing layer [cm]	$DL_\alpha$ [dB]	Sound absorption class
<b>RUCONBAR</b>	flat	20	6	A2
	high wave	15	8,7	A3
	trapezoidal	13	8,6	A3

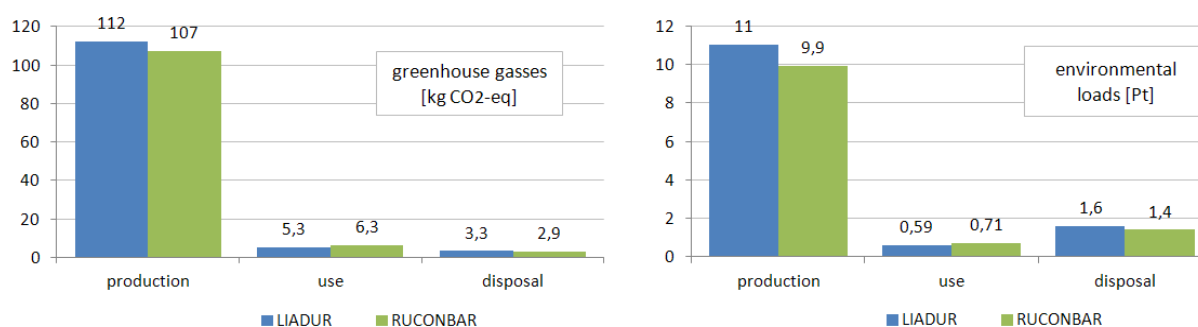


### 3.2. Life cycle analysis

In order to evaluate the environmental impact of new noise protection barrier, Life Cycle Analysis was conducted. The goal of this analysis was a comparative life cycle assessment of noise protection barriers with expanded clay (LIADUR) and RUCONBAR: from raw materials acquisition and processing, production, mounting and their dismantling/disposal, so called "cradle-to-grave" approach. Analysis was made using ECO-it software, and analysed products were barriers with 7 cm of average absorption layer thickness.

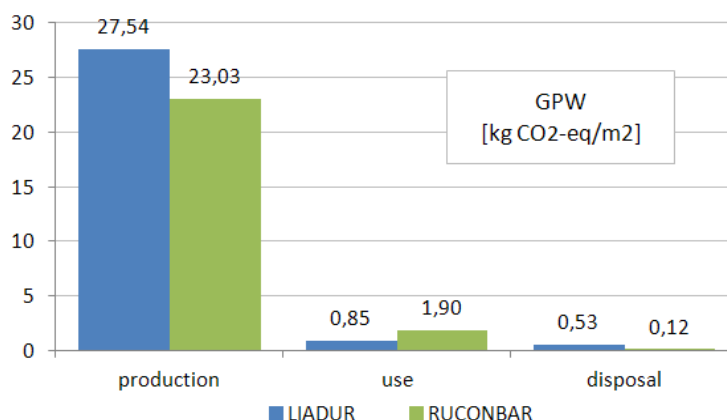
As it is shown Figure 8, the main contributions are due to production process (which includes acquisition and production of raw materials and their transport to location) while maintenance and disposal process have less impact. For disposal of noise protection barrier, "the most probable" scenario was assumed. Unfortunately, only 10% of construction waste produced in Croatia is recycled and reused, while 90% is still land filled [8].

For RUCONBAR, disposal scenario of 90% of absorption layer recycled and reused for a new absorption layer was used. Recycled rubber wasn't included in inventory as input material: it was considered as a final product of recycling end-of-life tires, so only energy consumption of mechanical grinding process and transport to the production site of noise protection barrier were included in the analysis.



**Figure 8.** Greenhouse gasses and environmental load [8]

The results of this environmental assessment show lower environmental load for noise protection barrier with recycled rubber, in comparison with noise protection barriers with expanded clay. As both types of noise barriers have the same bearing layer, the absorption layer determined this outcome. The comparative analysis of this relevant element as an independent unit is shown in Figure 9.



**Figure 9.** Global Warming Potential (GWP) [8]

### 3. CONCLUSIONS

Common noise mitigation measures on new, as well as existing roads in EU and in Croatia are sound absorbing concrete noise barriers with absorbing layer made from concrete with wood fibres or expanded clay granules. Using these materials is contrary to sustainable development as their production causes significant changes in the ecosystem. In order to replace these natural resources, a new product named RUCONBAR (Rubberised Concrete Noise Barriers), which incorporates rubber granules from recycled waste tyres to form a porous sound absorptive layer, was developed and tested.

Results of sound absorption tests placed RUCONBAR under A2 and A3 class of sound absorption, depending on the thickness and the shape of the absorbing layer's surface. Results of LCA show lower environmental impact of noise protection barrier RUCONBAR, in comparison to noise protection barrier which contains expanded clay.

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