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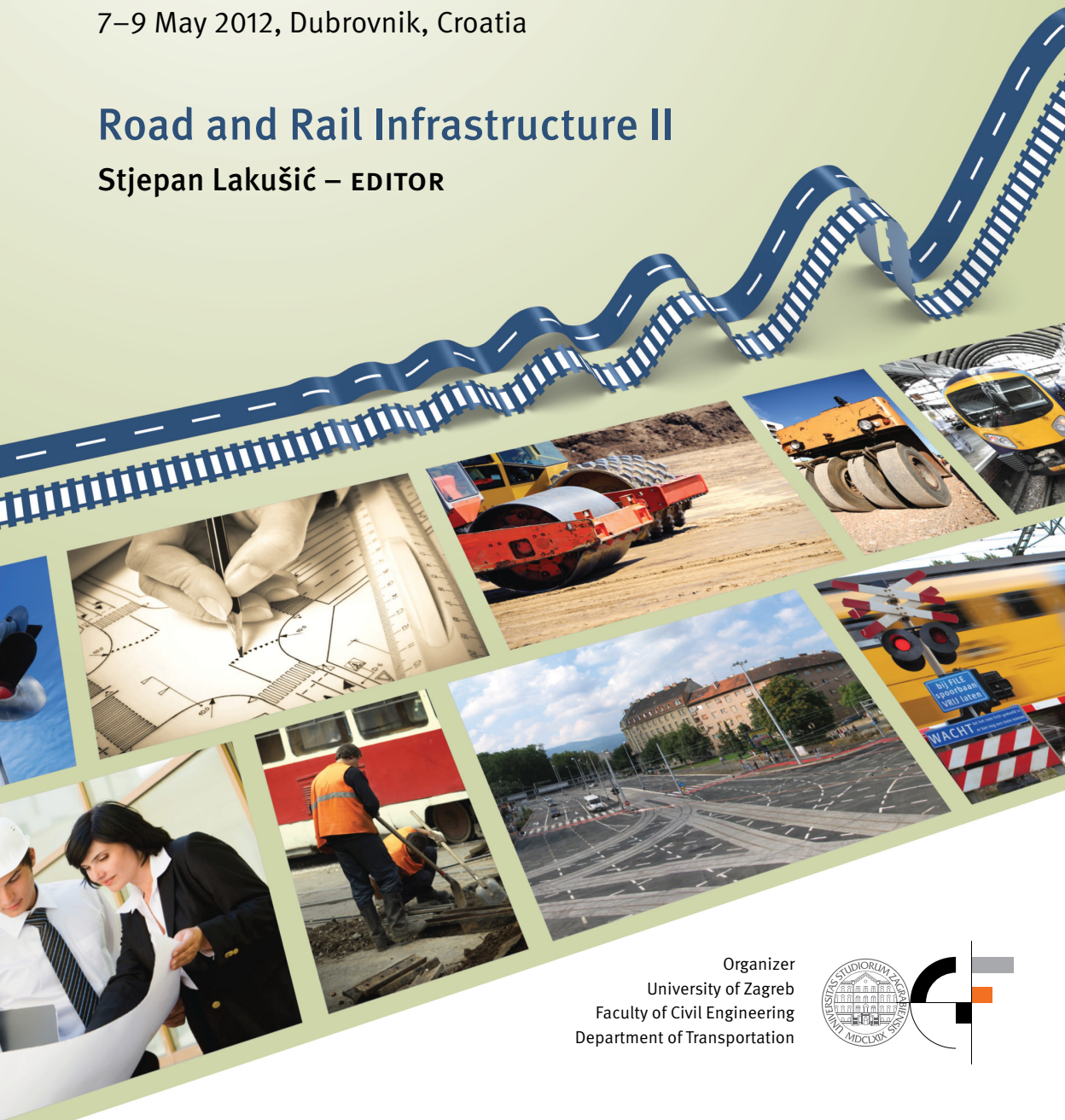
7–9 May 2012, Dubrovnik, Croatia

# Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR

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# INTEGRATED NOISE PROTECTION BARRIERS AND SOLAR POWER PLANT ON RIJEKA BYPASS

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*Rijeka–Zagreb Motorway, Croatia*

## Abstract

During the upgrade of the Rijeka Bypass to full profile 8.86 km long south carriageway from Orehovica to Diračje Interchange was built, starting at the beginning of 2008, and ending by the end of 2009. Since the Rijeka Bypass passes through the urban area, special attention was given to noise protection, resulting with the largest and the most complex noise protection project of its kind in the Republic of Croatia. As a result of complex requirements of noise protection in the vicinity of 5 high skyscrapers in the Rastočine area, an 352 meters long arch structure over the bypass south carriageway was constructed. Further the structure was designed in a way as to integrate a dual function: noise protection for the tenants, living in the four nearby skyscrapers, and electrical energy production.

*Keywords: Rijeka Bypass, noise protection, solar energy, environment, urban areas*

## 1 Introduction

Rijeka–Zagreb Motorway (Autocesta Rijeka–Zagreb d.d.) is the second largest motorway company in Croatia with 182 km of motorways and 13 toll plazas in service [Figure 1.]. Two plazas are an open toll system and the remaining 11 plazas form a closed toll system from Zagreb to Rijeka.
In August 2007, Rijeka–Zagreb Motorway has, according to the IV Contract on the Amendments to the Concession Agreement, extended its concession area. Within that extension it took over the operation of the bypass of the second largest city in Croatia, the City of Rijeka, along with the obligation to upgrade the bypass south carriageway from Orehovica to Diračje Interchange, 8.86 km long, so as to make the Rijeka Bypass one whole, with its full traffic function, according to the design. Construction of the south carriageway started at the beginning of 2008, and the works were completed by the end of 2009. Given that the Rijeka Bypass passes through the urban area, special attention was given to noise protection during construction works.


**Figure 1** Concession area of Rijeka– Zagreb Motorway.

### 1.1 Noise protection

Considering numerous types of environmental pollution we are subjected to nowadays, noise pollution is seemingly of 'low' importance. But noise has direct and indirect effects to human beings damaging their health, causing fatigue and lowering working ability, disturbing understanding, concentration, rest and sleep. This is precisely the reason why 'noise' has become, with the local population living in the vicinity of the motorway, one of the priorities which is being solved through the program of constructing noise protection walls. Exact noise level and the application of adequate safety measures is determined by a calculation model or monitoring after opening the motorway to traffic, or acoustic monitoring. The inclination is that functional and aesthetic criteria are to be reconciled in solving noise protection issues.

### 1.2 Noise protection on Rijeka Bypass

Construction of noise protection walls on the Rijeka Bypass is the largest and the most complex project of its kind in the Republic of Croatia. It includes the section from the Katarina Tunnel exit until the end of the Diračje Interchange which is 7 km long. Noise protection wall on that section is constructed using various materials – concrete, aluminum and glass, and the total surface of walls amounts approximately to 50,000 m², which currently makes this the largest project of its kind in the Republic of Croatia.

## 2 Integrated noise protection and solar system

### 2.1 Solar noise barrier

On the part of the section in the vicinity of the skyscrapers, in the Rastočine area, as a result of complex requirements of noise protection and the vicinity of 5 skyscrapers for the first time in Croatia an arch structure over the entire bypass south carriageway was constructed. Acoustic calculations have shown that it is practically impossible to protect the top floors of the skyscrapers using a standard, vertical sound barrier. As a possible solution, in preliminary acoustic design, a structure with a 5–meter high vertical wall and the inclined, cantilever extension 8.0 m long, was suggested. This solution is, from the building aspect, unfavorable, since the noise barriers also present the wind barriers, and the wind load onto these

is huge. Closed framed structure was than the best possible solution. Therefore a structure resembling a tunnel was chosen, 5.0 m high at its lowest point, and about 7 m high in the central axis, with a span of 10.50 m and length of 352 m [1]. This kind of a tunnel consists of a noise barrier towards the southern side, and is only partially enclosed on that side (5.0 m in width), thus protecting the inhabitants on the top floors of the skyscrapers, built next to the road, from noise. Special attention was given to this challenging part of the alignment, by the design engineers and the representatives of the City of Rijeka, in order to 'reconcile' the specific requirements of noise protection and aesthetic appearance of this part of the noise protection wall. Standard aluminum plates for noise reduction are placed on vertical planes of the 'tunnel', while the 'tunnel' roof is filled, to the half of its width, with solar modules. Noise protection from the north side of the motorway was constructed using aluminum plates for the vertical plane, while the inclined plane was filled with solar modules. Total length of the segment, where the solar noise protection wall is placed, is 352m.

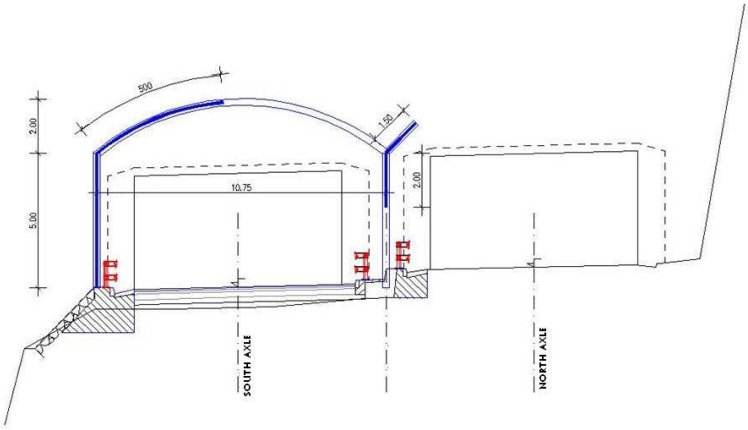


**Figure 2** Cross section – closed framed structure for noise protection.

## 2.2 System description

The system is made of 1232 solar modules type ENERGOBEREN 215W, which, with the steel frame, make a 352–meter long noise barrier. The noise barrier is in form of a tunnel above the bypass south carriageway, and it is closed only to the half of its width (Image 4). System has 30–grid connected inverters which transfer DC voltage (about 600 V) into AC synchronized three–phase voltage (400 V, 50Hz).The inverters are connected to the electricity substation 400 kVA with 400 V/10 kV which is built in cooperation with Elektroprimorje Rijeka (company for distribution of electricity) from Rijeka.

## 2.3 Module connection methods

The modules are placed in five rows above the south part, and in two rows above the north part of the motorway. There are four groups of inverters: A, B, C, D. Group A (identical to groups B, C and D). 42 solar modules connected in series are connected to each inverter. 21 solar modules connected in series are connected to each MPPT (maximum power point tracker). One inverter is connected to the modules situated in the same row. Each group of modules contains seven inverters, except for the group D which contains nine inverters.

**Figure 3** View towards the solar noise protection wall from the south.

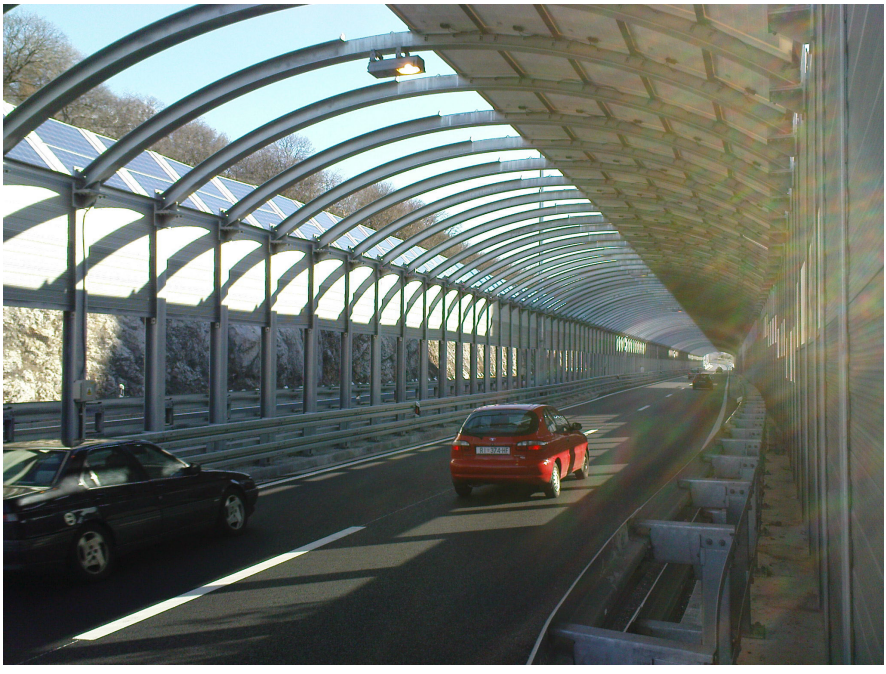

**Figure 4** Constructed integral system – view from inside.

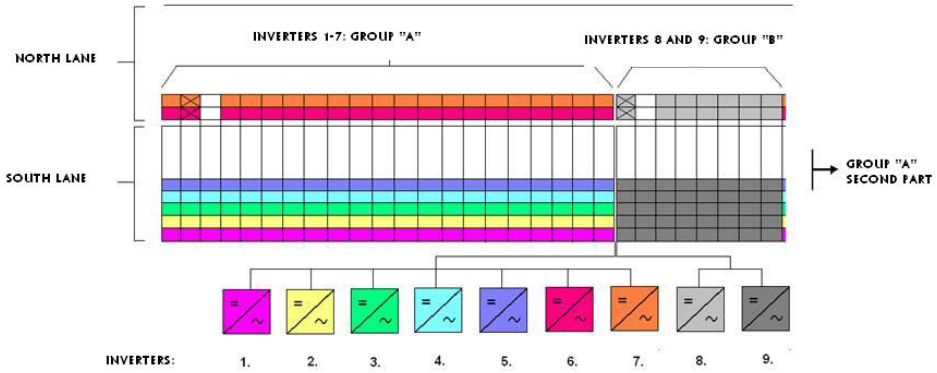


**Figure 5** Connecting modules onto particular inverters of group A (first part) and group B.

## 3 Produced energy and cost–effectiveness

The price of this solar system is approximately 1,130,000.00 €. The amount of energy that would be produced in a period of one year, if there is no shadowing, is 287,869 kWh [2]. The amount of energy produced in a one year period, taking into account shadowing, is 205,548 kWh (or 71% of production without shadowing). The expected amount of energy to be produced by the system in a period of one year equals to 230,295 kWh. Deviation is +/- 5%.

## 4 Conclusion

In order to make use of the favorable position of panels in the noise protection system, which is designed in shape of an artificial tunnel, in the zone of skyscrapers on the Rijeka Bypass, the panels are made of solar collectors for electricity production, thus forming an integral system of noise protection and electrical energy production from renewable resources. Return on this investment is planned after 11 years.
Apart from protecting the nearby skyscrapers from noise, and the expected return on investment in the specified time period, this project also has the following effects:

- Aesthetical intervention improves the overall appearance of this part of Rijeka, which is, to a certain extent, affected by skyscrapers,
- Increase environmental awareness,
- Tourist promotion of the City of Rijeka and the Republic of Croatia.

## References

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