

NOISE AND VIBRATIONS PROTECTION ON CROATIAN RAILWAYS NETWORK

Sanjin Novosel¹, Stjepan Lakušić², Hrvoje Domitrović³

1 Croatian Railways, Croatia

2 University of Zagreb, Faculty of Civil Engineering, Croatia

3 University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia

Abstract

Reduction of noise and vibrations from railway traffic is one of the main tasks in which engineers are engaged today, with the purpose of achieving comfortable living conditions in settlements situated immediately next to railway lines. In the last few years, efforts have been made in Europe to switch as much cargo transport from roads to railways as possible, due to which the importance of railways has been constantly increasing. The result of redirecting transport is disburdening of the road network, increasing of passenger and cargo transport on the railway, but also increasing of noise and vibrations from railway traffic. In order to select an adequate measure for their reduction, it is necessary to register the situation in the environment on the subject location, analyze a possibility of application of particular measures and make a relevant decision about which measure is most cost-efficient to apply. For a more complete consideration of the problem of increased noise and vibrations, an incentive was started in Croatian Railways 2009 to establish a trial section on which field tests would be carried out in cooperation with scientific institutions within scientific-research projects, and thus achieve the effect of a particular measure. The paper analyzes the plan of researches on the future test section as a whole, and it also gives a detailed presentation of measures for reduction of noise and vibrations that are undertaken on reconstructed railway lines, and of the measures that are planned to be undertaken on future lines in the Croatian Railways network.

1 Introduction

The goal of the European transport policy is to redirect short-distance air traffic to high speed railways as well as the freight transport from road to railway and that is why the importance of the railway is increasing more and more. On the other hand, the European Commission Green Paper on Future Noise Policy states how the major public complaints are related to high noise and vibrations levels caused by rail traffic and as such represent a serious ecological problem. The increased noise and vibrations levels have a negative impact on human health and make normal, everyday life impossible. The major adverse effects are: concentration problems, impediments to communication, sleep disturbance, feeling of annoyance, sickness and so forth. Therefore, the reduction of noise and vibrations levels in railway traffic is one of the prerequisites for the railway freight and passenger transport importance increase. Having in mind the fact that the implementation of measures for noise and vibrations reduction is extremely difficult (if not impossible) to be economically justified, the European Commission created, among others, the Working Group Railway Noise, whose task was that of developing a strategy and priorities for noise level increase problem solving.

The Working Group drew up the Position Paper on the European Strategies and Priorities for Railway Noise (PPS) in which it states that, due to the international character of rail transport,

the strategies must include states currently outside the European Union and especially the accession countries. The need for all the parties to be involved in the process of protection against noise is also stressed out and these parties are:

- the European Union
- the Member States (governments, parliaments, agencies)
- regional and local authorities
- the Railways (operators, infrastructures managers, railway vehicle owners, maintenance companies)
- manufacturers (of vehicles and vehicle components as well as those of rails and rail components).

For the purpose of solving the problem and involving all the parties in the noise and vibrations protection process, in the year 2009 the Croatian Railway started an initiative for establishing a trial section on which field tests would be carried out in cooperation with scientific institutions within scientific-research projects and thus the effect of a particular measure would be achieved and the set of measures which provide the best return on investment would be determined.

2 Causes of noise and vibration on railway track

Train speed has an important impact on noise and vibrations emissions. Noise and vibrations caused by traction and other auxiliary systems (diesel engines, cooling equipment, compressors and so on) prevail at low speeds of up to 60km/h. Noise and vibrations produced by wheel-rail rolling prevail at higher speeds of up to 200-300km/h, while at much higher speeds aerodynamic noise prevails. The sources and major causes of noise and vibration emission in railway traffic are indicated in table 1.

Because of the maximum projected speed of 160km/h, the sources on Croatian railroads are: noise and vibrations caused by wheels rolling on rail, noise and vibrations caused by traction and other systems and local sources such as squeal, impact and so on.

Table 1 Major noise and vibration sources

Cause of noise and vibration emission	Passing of the train	Shunting and other
Sources	caused by rolling caused by traction and auxiliary aerodynamic noise local sources (squeal, impacts, bridges)	caused by rolling caused by traction and auxiliary squeal, impacts

Railway traffic noise and vibrations protections measures can be divided into four basic categories:

- a measures at the source,
- b measures on the way of propagation,
- c measures at the point of immission,
- d economic measures and regulations.

The first category pertains to primary measures whereas the remaining three pertain to secondary measures. This paper will discuss the first two sets of measures i.e. the measures the impact on noise and vibration level reduction of which is possible to examine on the aforementioned trial section. Noise and vibration level reduction at the source can be obtained by:

- choosing the adequate construction types of the upper structure
- regular maintenance of the rails surface
- choosing of adequate vehicles
- wheels maintenance
- reducing the speed of railway vehicles and managing the railroad capacities

Reduction of noise and vibration propagation is possible by:

- construction of noise and vibration barriers,
- enclosing the railway vehicles parts (wheels, bogies).

3 Participants in the noise protection process

The financial component represents the major problem in noise and vibrations protection measures implementation. In order for the problem of increased noise and vibration levels to be efficiently solved some time in the future, it is necessary to involve all interested parties. The participants in the noise and vibration protection process (Table 2), can be grouped in three categories: 1 policy in which the state, regions and local self-government bodies pertain; 2 railways (railroad infrastructure, railroad traffic, trains traction); 3 manufacturers (rails and rail components manufacturers, vehicle and vehicle components manufacturers).

HŽ Infrastruktura d.o.o. starts an initiative for including all other railway companies in the process of noise and vibrations protection. Only with active participations of all railway companies in field tests it would be possible to share responsibilities and costs related to noise and vibrations protection measures.

Table 2 Participants in the noise protection process

Parties in the Rep. of Croatia	Activities
Policy	
Republic of Croatia	Harmonise legislation to EU requirements
Regions	Create the national programme of noise and vibration protection (see Switzerland's example)
Local self-government bodies	Inform and involve the public
	Introduce the maximum permitted noise level for non-interoperable vehicles
	the national railway authorities should implement harmonised type test procedures and deliver the test data to the European authorities
Railways	
HŽ Infrastruktura d.o.o.	Implement measures for railroad tracks
	Subvention for "silent" vehicles
	Grinding and maintaining the railroad track rails
	Management of the railroads capacity with respect to noise level limits
	making harmonised test tracks available
HŽ Putnički prijevoz d.o.o.	Requesting for the new specification to be brought forward regarding the purchase of new and rebuilt vehicles
HŽ Cargo d.o.o.	Implement measures related to vehicles noise related maintenance schemes by trackside or on-board monitoring systems
HŽ Vuča vlakova d.o.o.	
HŽ Holding d.o.o.	
Manufacturers	
of vehicle and vehicle components	Participation in research projects
of rails and rail components	Participation in standardization

4 Trial section on railway track

For the purpose of obtaining the most precise answers on the possibility of noise and vibrations reduction by implementation of some of the well-known measures that have been researched today or that are partially implemented, it is planned to create, within the research framework, a trial section on the Croatian Railways network. At the moment, the possibility of creating a trial section in the Eastern part of Zagreb (Retkovec settlement) is also being explored, more precisely on the railroad section for which many complaints by the people who live and work next to the said track were already brought forward. During 2006, noise measures

on the said site were performed and it was discovered that every time a train passes, noise level increases by 8 to 10 dB(A) (Figure 1). Specific for this location is the double track railway line placed on the south side of Branimirova Street, as shown in Figure 2. Maximal noise levels appeared every 6 to 10 minutes when the trains passed-by. They range from 80 to 84 dB, and to a smaller extent they also depend on the heavy vehicles road traffic on Branimirova street. Retkovec settlement is close to Branimirova Street, which represents one of the major traffic routes of the eastern part of Zagreb. The street has two roadways, one for each direction, with two lanes each. Parallel to the roadways is a double track railway line Zagreb – Vinkovci situated at the south side of Branimirova Street, Figure 2.

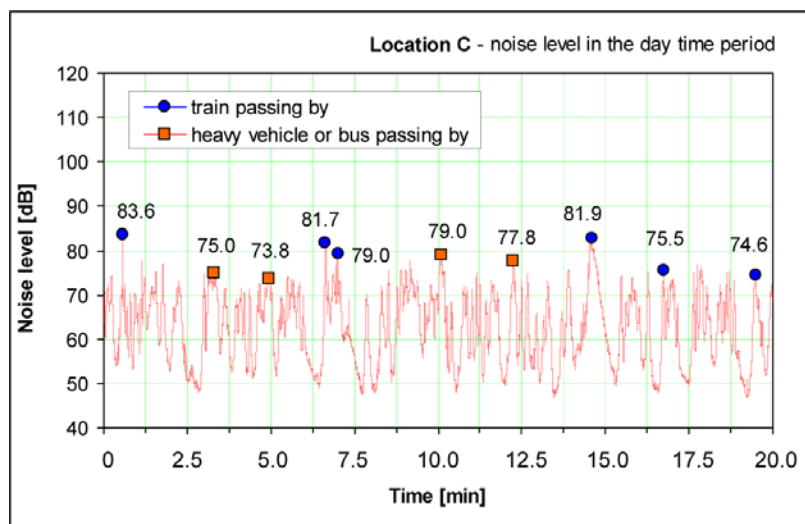


Figure 1 Characteristic indication of the noise level time change (Retkovec settlement, Zagreb)

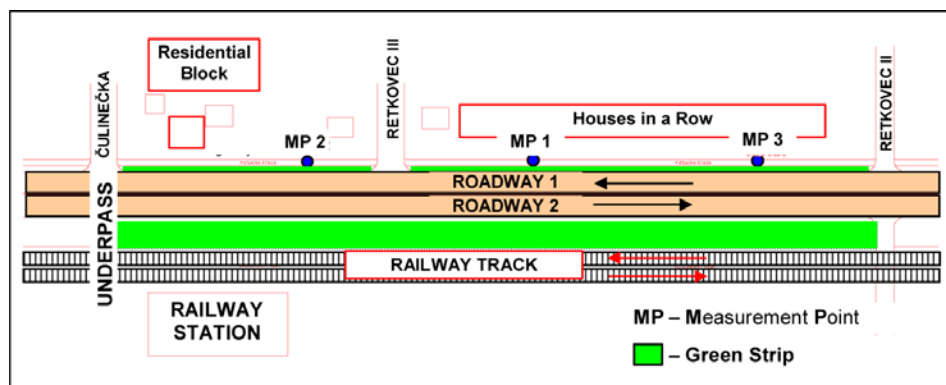


Figure 2 Schematic overview of Branimirova Street – Retkovec settlement

The researches on the trial section would be carried out within the framework of scientific projects financed by the Ministry of Science, Education and Sport of the Republic of Croatia and conducted at the University of Zagreb, more precisely at the Faculty of Civil Engineering and at the Faculty of Electrical Engineering and Computing. At the track trial section the effect of several noise and vibration reduction measures would be implemented and controlled: elastic pads under concrete sleepers, rail web dampers and use of noise protection walls.

The schematic diagram of the planned trial section is shown in Figure 3. In order to establish the effect of every implemented measure, the results of measurement recorded on the track where one of the measures was implemented (pads under the sleepers, rail dampers) would be compared and the construction of noise protection walls near the tracks with the results of measurement on the ordinary track construction.

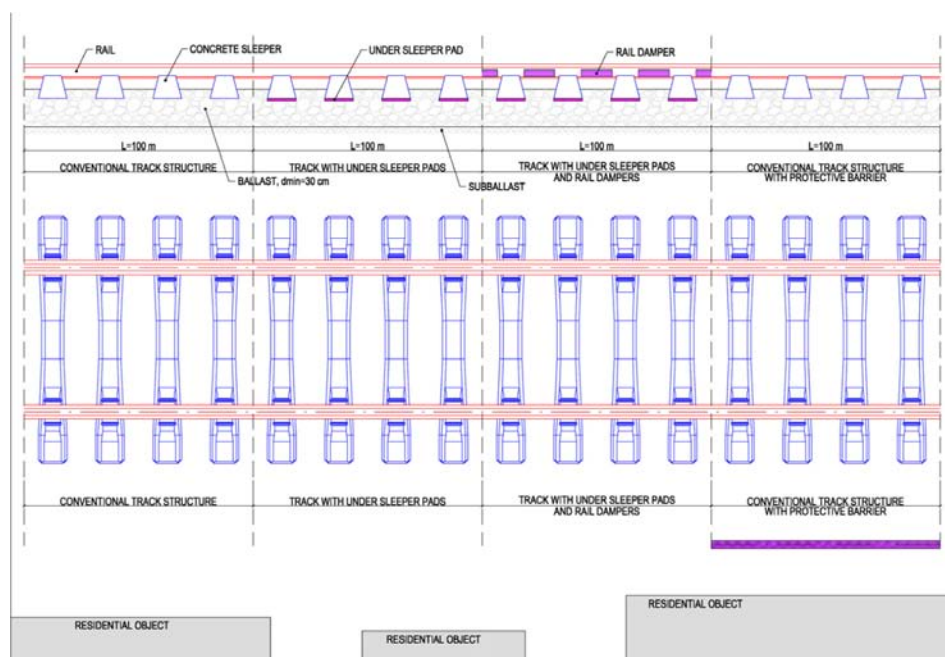


Figure 3 Schematic overview of the trial test track section

From the available results of researches conducted in the last couple of years on the European railways network, the possibilities of the aforementioned measures that are planned to be observed on the trial section are well known. However, on this section the materials that would be completely produced in Croatia would be examined. First of all, it refers to the sleepers which are fitted with built-in elastic pads on their lower seat. Currently, such sleepers are not produced in Croatia. By the same token, neither the rail web dampers are produced in Croatia, although these products can entirely be produced in Croatian factories, especially in those specialised in recycled materials.

On the basis of measurements and tests performed on the trial section, the recommendations will be given for the implementation of some of the measures for noise and vibrations reduction on Croatian Railways tracks and first of all, on those sections against which complaints were brought by the people who live next to railway tracks. This is of particular interest for the railway stations that are situated mostly nearby the business-residential complexes as well as for those railways that are passing through populated residential areas.

5 Conclusions

The increased levels of noise and vibrations due to railroad traffic represent a big problem to which Croatia did not paid much attention until a few years ago. By harmonizing the Croatian legislation with that of the European Union, the legal frame for solving this problem was created. In order to be able to answer the question which measure or a set of measures for noise level reduction is the most appropriate one, it is necessary to register the environmental condition on the said site, to analyse the possibility of implementing the individual measures and to reach a pertinent decision. The costs of methodical researches as well as the costs of noise and vibrations protection measures are extremely high and therefore represent the limiting factor in their implementation. As the only successful solution to that problem, there is a need for involvement of all the parties to the process of noise and vibrations protection what also implies the responsibility and costs sharing. The creation of the trial section and the research project which will be held there would mark the good beginning of involvement and successful collaboration of all the participants in the noise and vibration protection process.

References

- [1] The Green Paper “Future noise policy” - European Commission, 1996.
- [2] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise.
- [3] Lakušić, S., Ahac, M.: “Measures to reduce noise and vibration from railway traffic”, SABOR HRVATSKIH GRADITELJA 2008, (ur. Simović, V.), Cavtat, Hrvatska, pp. 383-395, 2008.
- [4] “Act on noise protection”, Official Journal of the Republic of Croatia, No. 30/2009.
- [5] Position Paper on the European strategies and priorities for railway noise abatement – WG - Railway Noise of the European Commission, 2003.

AUTHOR INDEX

Aburawi, Bashir M.....	341	Deluka-Tibljaš, Aleksandra	53, 171
Acalin, Nina.....	671	Dimitrov, Emil.....	963
Ahac, Maja.....	1007, 1015	Dimter, Sanja.....	59, 291
Ahac, Saša.....	993, 1015	Dobrinka, Atmadzhova.....	727
Albinović, Sanjin.....	591, 859	Dokaza, Zlatko.....	613
Alić, Nedžad.....	473	Dolaček-Alduk, Zlata.....	59
Amine, Dima.....	467	Domitrović, Dubravko.....	437
Asgari, Hosein.....	763	Domitrović, Hrvoje.....	999, 1059
Babajić, Elvir.....	473	Domitrović, Josipa.....	365, 373
Babić, Arandel.....	957, 971	Dragčević, Vesna.....	381, 993
Babić, Sergije.....	53, 165, 171	Dubravac, Stela.....	671
Barišić, Ivana.....	59, 381	Duplančić, Zdravko.....	133
Bartolac, Marko.....	503	Dupont, Ariane.....	933
Bašelj, Roman.....	257	Duvnjak, Ivan.....	503
Beden, Andrej.....	979	Džebo, Suada.....	859
Bekić, Damir.....	481	Esveld, Coenraad.....	19
Bićanić, Ena.....	1037	Fakhari, Maryam.....	773
Binički, Marijan.....	157	Fimpler, Joerg.....	541
Bižić, Milan.....	957	Franolić, Zlatko.....	1051
Blab, Ronald.....	409	Fujiu, Makoto.....	873
Bleiziffer, Jelena.....	509	Garcia, Camila.....	187
Bogdan, Mario.....	381	Ghorbani, Vida.....	719
Bogdanović, Vuk.....	91	Gillis, Dominique.....	231
Bolkovac, Ivan.....	999	Gilja, Gordon.....	481
Božović, Dragan.....	547	Gjetvaj, Goran.....	99
Brčić, Davor.....	83, 427	Grandić, Davor.....	489
Brdarić, Dinko.....	125	Grginić, Igor.....	1037
Brkić, Marta.....	1023	Grukowski, Slawomir.....	583
Brožek, Barbara.....	395	Gucunski, Nenad.....	307
Buchta, Josef.....	735	Haladin, Ivo.....	1015
Bunijevac, Helena.....	629	Haramina, Hrvoje.....	867
Burlacu, Adrian.....	299	Hauser, Jaroslav.....	241
Carels, Patrick.....	701	Hitchcock, Christopher.....	467
Carpanese, Franco.....	907	Hivert, Laurent.....	933
Chrostowski, Piotr.....	583	Hlaváčová, Júlia.....	987
Ciešla, Maria.....	555	Hoffmann, Markus.....	417
Cuculić, Marijana.....	171	Hoić, Marko.....	831
Cvetković, Mladen.....	443	Horvath, Zoltan.....	701
Čarman, Samo.....	979	Horvat, Marko.....	999
Čoko, Boško.....	547	Hruzíková, Miroslava.....	735
Damjanović, Domagoj.....	495, 503	Humar, Staško.....	781

Hyzl, Petr.....	265, 283, 401	Lipovac, Krsto.....	179
Ilić, Nemanja.....	971	Litzka, Johann.....	29, 395
Ivačić, Matjaž.....	979	Livneh, Moshe.....	271
Jackson, Hudson.....	307	Löffler, Günter.....	949
Jakovljević, Ivo.....	1045	Lončarić, Aleksandar.....	133
Jakovljević, Marinko.....	1045	Lutz, David.....	467
Jašarević, Ibrahim.....	451, 473	Ljubič, Aleksander.....	257
Jovanov, Dejan.....	179	Ljutić, Kristijan.....	165
Jovanovic, Stasha.....	801	Macário, Rosário.....	187
Jukić, Mario.....	1037	Maher, Ali.....	307
Jurić-Kačunić, Danijela.....	443	Maicz, Dietmar.....	809
Kache, Martin.....	949	Majstorović, Igor.....	67, 141
Kaefer, Roland.....	921	Mandula, Ján.....	647
Keller, Miroslav.....	357	Marić, Marina.....	671
Kelly, Roger.....	701	Markusik, Sylwester.....	555
Kirchmaier, Lukas.....	409	Marušić, Dušan.....	597
Kljajić, Slobodan.....	77, 533	Mašala-Buhin, Mirjana.....	99, 605
Knez, Martin.....	837	Mavar, Krunoslav.....	509
Kocijan, Jerko.....	461, 467	McKeogh, Eamon.....	481
Koc, Wladyslaw.....	583, 757	Medvedev, Alexander.....	217
Kolli, Zéhir.....	933	Medvidović, Tino.....	743
Korlaet, Željko.....	45	Melikyan, Alla.....	881
Korošec, Marko.....	979	Mikić, Tatjana.....	845
Kovačević, Meho-Saša.....	443	Mikinac, Branko.....	83
Kovačević Zelić, Biljana.....	437	Mikulić, Tanja.....	637
Kovalaková, Mária.....	987	Mirfattahi, Behrouz.....	773
Kozumplikova, Alice.....	241	Misnevs, Boriss.....	881
Kožar, Ivica.....	743	Mladineo, Nenad.....	597
Krakutovski, Zoran.....	787	Mlinarić, Tomislav.....	897
Kralj, Stjepan.....	109, 533, 563, 605, 661, 851	Mondschein, Petr.....	401
Krasić, Davor.....	427	Moslavac, Darko.....	787
Krhen, Hrvoje.....	451	Nawrat, Wojciech.....	653, 661
Krolo, Joško.....	495	Nenov, Nencho.....	963
Kršmanc, Rok.....	979	Nikolić, Ana.....	67, 151
Kuo, Angela.....	679	Novosel, Sanjin.....	1059
Kuspilić, Neven.....	481	Nowacki, Gabriel.....	201
Kvasnička, Predrag.....	437, 461	Njegovec, Mario.....	141, 151, 451
Kwahk, Imjong.....	517	Ophalfens, Koen.....	701
Kwark, Jong-Won.....	517	Ožbolt, Marko.....	365, 373
Lakušić, Stjepan.....	693, 743, 915, 993, 1007, 1015, 1059	Pace, Pietro.....	907
Lanović, Zdenko.....	117, 125	Papić, Zoran.....	91
Latić, Vildana.....	489	Pavlica, Đorđe.....	503
Lauwers, Dirk.....	231	Pavšek, Aleš.....	541
Lažeta, Tihomir.....	533	Pejić, Zvonimir.....	77, 109, 133, 605
Leban, Leon.....	795	Pereira, Ana Relva.....	187
Leković, Milja.....	91	Perić, Krunoslav.....	77
Lindfeldt, Anders.....	889	Perković, Hrvoje.....	451
		Petrović, Aleksandra.....	971

Petrović, Dragan.....	957	Stehlik, Dusan.....	265, 401
Petrunina, Marina.....	389	Stehlík, Dušan.....	735
Pfeiffer, Lutz Stefan.....	179	Stepan, Željko.....	151
Pintar, Žarko.....	195	Stephanides, Johannes.....	809
Pinto, Paulo.....	701	Stipaničev, Dinko.....	1051
Plášek, Otto.....	735	Stolpmann, Ryan.....	653
Pljakić, Marina.....	957, 971	Surlea, Claudia.....	299
Pokrivač, Mario.....	1023, 1029	Svoboda, Richard.....	735
Pološki, Damir.....	67, 141	Šajn Slak, Alenka.....	979
Poljanec, Zoran.....	1029	Šarić, Darko.....	637
Popovac, Nina.....	671	Ščukanec, Anđelko.....	427
Popović, Danilo.....	315	Šemrov, Darja.....	541
Pticina, Irina.....	223	Šimun, Miroslav.....	325
Puljizević, Maro.....	1051	Šipoš, Dejana.....	687
Ráčanel, Carmen.....	299	Šiša, Pero.....	751
Rajič, Slaviša.....	249	Škarić Palić, Sandra.....	509
Rak, Mladenko.....	495, 503	Škorput, Pero.....	157
Ramšak, Žiga.....	795	Škrinjar, Damir.....	915
Rehlicki, Kazimir.....	125	Škugor, Denis.....	687
Ristić, Ivan.....	845	Šmit Novoselec, Valentina.....	533
Roduner, Armin.....	821	Šolić, Tomislav.....	249
Rohrer, Lukas.....	821	Šošo, Stipe.....	781
Rukavina, Hrvoje.....	357	Špelić, Nataša.....	195
Rukavina, Tatjana.....	325, 365, 373	Štimac, Alan.....	1051
Ruškić, Nenad.....	91	Štimac Grandić, Ivana.....	489
Ruzhekov, Toma.....	963	Šubat, Dragutin.....	621
Salaiová, Brigita.....	987	Šurdonja, Sanja.....	171
Salopek, Tomislav.....	117	Takada, Kazuyuki.....	873
Satazić, Tatjana.....	915	Tomandl, Vladimír.....	711
Savrasovs, Mihails.....	217	Tomašević, Gordana.....	335
Schöbel, Andreas.....	815, 867	Tomić, Tomislav.....	533, 563
Sesar, Petar.....	99	Uzelac, Tajana.....	1023
Sevelova, Lenka.....	241	Vacin, Otakar.....	283
Shahriari, Shahrbanoo.....	763	Vajdić, Marko.....	563, 637, 661
Sikerzhicky, Jury.....	389	Valentin, Jan.....	401
Simić, Tatjana.....	845	Varaus, Michal.....	265, 283, 401
Sipilä, Hans.....	575	Veit, Peter.....	897
Slabe, Tadej.....	837	Vjekoslav, Budimir.....	821
Smirčić, Vlasta.....	1051	Vogel, Aron.....	821
Smutný, Jaroslav.....	711	Vranar, Zrinka.....	621
Sokolić, Željko.....	751	Vrselja, Krešimir.....	687
Soucek, Vaclav.....	283	Vučetić-Abinun, Slavica.....	349
Spasić, Petar.....	349	Vučetić, Mladen.....	461
Specht, Cezary.....	757	Vukadin, Davorin.....	157
Stamač, Dominik.....	109	Vukušić, Ivan.....	711
Stančerić, Ivica.....	1007, 1015	Walendzik, Małgorzata.....	201
Stanić, Andreas.....	291	Wilk, Andrzej.....	583
Stanković, Miljenko.....	605		
Stazić, Tatjana.....	597		
Steglich, Uwe.....	949		

Wollny, Rafael S.	921
Yatskiv, Irina	217, 223
Yokoyama, Shigeki	873
Yoon, Hyejin	517
Yurshevich, Elena	209, 217
Zafirovski, Zlatko	787
Zakeri, Jabbar Ali	719, 763, 773
Zekan, Sabid	473
Zoeteman, Arjen	801
Zottl, Wolfgang	809
Žagar, Silvio	117
Žagar, Željka	117
Živković, Slavko	693



Products, services & systems for soil reinforcement and ground stabilisation



PROVEN PERFORMANCE

Our geogrid and geotextile products are rigorously tested under research and site conditions by leading universities and national independent authorities. Our proven track record and exceptional products ensure optimum performance on any project, backed by the extensive design and technical services of our civil engineering team.

COST SAVINGS

Delivering valuable saving in time, materials, on-site activities, maintenance and whole life costs, Tensor Technology can bring projects to completion on time and budget, with reduced environmental impact.



APPLICATION VERSALITY

Ground Stabilisation

Reinforcing unbound layers in roads and trafficked areas

Soil Reinforcement

TensorTechSM Earth Retaining Systems for Walls & Slopes

Foundations over Piles

Constructing over weak ground without settlement

Basal Reinforcement

Constructing embankments over weak ground

Railways

Mechanical stabilisation of track ballast and sub-ballast

Asphalt Pavements

Reinforcing asphalt layers in roads and trafficked areas

Erosion

Controlling erosion on soil and rock slopes

To know all the facts, performance and cost benefits of our geogrid and geotextile products contact our exclusive distributor in Croatia - Kotonteks or visit:

www.tensor-international.com

KOTONTEKS' d.o.o.
Josipa Pupačića 3
42000 VARAŽDIN, CROATIA
tel.: +385 42 208 022
fax: +385 42 208 045
e-mail: kotonteks.vz@gmail.com



KotonTekS



ACTIVITIES: Traffic infrastructure projects - Studies, preliminary, main & working designs for:

- Traffic intersections
- Tunnels
- Railways
- Airports
- Bridges
- Engineering structures
- Water facilities





AUTOCESTA
ZAGREB-MACEJ d.o.o.

Headquarters: Velika Ves bb, 49 224 Lepajci, Croatia

Office address: Garićgradska 18, 10 000 Zagreb, Croatia

E-Mail: office@azm.hr; Tel: +385 (0)1 3689 600; Fax: +385 (0)1 3689 620





UNIVERSITY OF ZAGREB, FACULTY OF CIVIL ENGINEERING,
GEOTECHNICAL ENGINEERING DEPARTMENT,
CHAIR FOR ROCK MECHANICS AND INVESTIGATION WORKS

PROJEKTIRANJE U GEOTEHNICI



Sanacija svoda speleološkog objekta



Ojačanje tla mlaznim injektiranjem



Zaštita iskopa duboke građevne jame

GEOTEHNIČKI ISTRAŽNI RADOVI



CPTU ispitivanja



Geofizička ispitivanja



Laboratorijska ispitivanja

MONITORING U GEOTEHNICI



Mjerenje naprezanja u tunelu



Mjerenje krutosti tla SASW metodom



Ispitivanje nosivosti sidara

Više od 120 godina tradicije

Željeznički PROGRAM

Poseban dio proizvodnje je kolosiječni pribor gdje dominiraju spojni elementi i ostali proizvodi kao što su:

- tirfoni za drvene i betonske pragove
- stojeći vijci
- vijci za vezice te ostala vijčana roba u spojnom priboru u svim kvalitetama i vrstama zaštite
- elastične pritiskalice SKL1, SKL1A, SKL2, SKL12, SKL MD; K-kopče; prstenaste podloške, jednostruke i dvostruke elastične prstenaste podloške
- vezice 60E1, 49E1, vezice za lijepljenje sastava i ostale vezice
- rebraste podložne ploče 60E1 i 49E1, sa i bez nagiba
- Tračnice: standardne željezničke tračnice tipa 49E1, R65, R65-A, 60E1, 6,00E+03, 54E1, UIC54E, 115RE, 136RE, 136-8, M48, 50E6, 54E3, 141RE, skretničke tračnice tipa S49, I49, R65, UIC60, tramvajske tračnice tipa B1, B3, NT1, NT3, NT, tračnice za rudnike tipa 70/10 (S 10), 80/14 (S14), 93/18 (S 18), Xa
- dijelovi željezničkih vozila: odbojnici, vučne sprave, kočioni trokuti i nosači
- laka željeznička mehanizacija: bušilice pragova, bušilice tračnica, rezačice tračnica, brusilice tračnica i uvijačice tirfona i vijaka

Uz kolosiječni pribor nudimo i program kočionih umetaka i uložaka za sav željeznički program.

Isporučujemo kompletne sisteme za betonske i drvene pragove, i to do raznih brzina vožnje, uključujući brzine do 350 km/h. Trenutno smo u fazi realiziranja DIV-sistema spajanja tračnice za prag.

DIV

DIV d.o.o.
TVORNICA VIJAKA

Bobovica 10a,
10430 Samobor
div@div.com.hr
www.div.com.hr



EDUCATION

Undergraduate courses:

- Roads
- Railways

Graduate courses:

- Traffic Noise
- Traffic Tehnics
- Road Design
- Railway Design and Construction
- Pavements
- Permanent Way
- Road Intersections
- Earthworks
- Traffic Tunnels
- Airports
- Transportation Facility
- Traffic Systems
- Pavement Management
- Railway Maintenance

Postgraduate courses - doctoral:

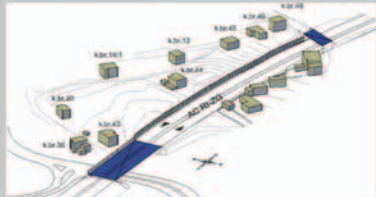
- Theory of Road Alignment
- Flexible Pavements
- Theory of Vehicle Movement on Rails
- Highway Capacity
- Intersection Design
- Concrete Pavements
- High Speed Tracks
- Special Chapters about Traffic Noise
- Pavement Surface Properties
- Theory of Road Vehicles Movement
- Optimization of Railway Lines

Lifelong education:

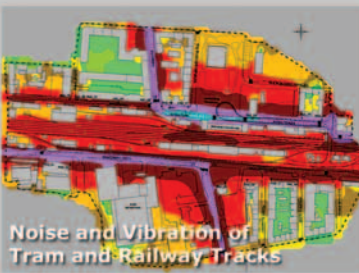
- Dani prometnina (Transportation Infrastructure Days)
- 2008 • 2009 • 2010 •



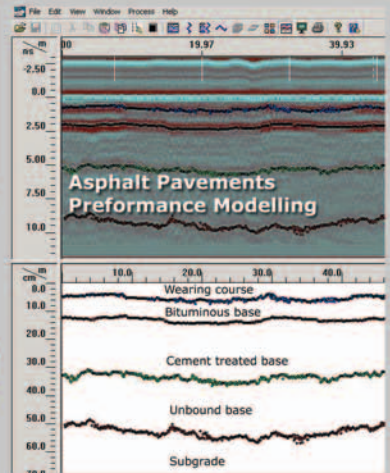
RESEARCH PROJECTS



**Road Traffic Noise
Monitoring and Mitigation**



**Noise and Vibration of
Tram and Railway Tracks**



PROFESSIONAL PROJECTS



Noise protection



Pavement survey



**Laboratory for testing
geosynthetic materials**



Urban railways



Road design

Vrhunski proizvodi za udobno putovanje



PROIZVODNI PROGRAM

- Elektromotorni vlakovi
- Električni tramvaji
- Električne lokomotive



KONČAR

Končar - Električna vozila d.d.

Velimira Škorpika 7, 10090 Zagreb, Hrvatska
tel. +385 1 3496 959, 3496 957
fax +385 1 3496 960, 3496 963
info@koncar-kev.hr
www.koncar-kev.hr

Proceedings of the
First International Conference on Road and Rail Infrastructures – CETRA 2010
17-18 May 2010, Opatija, Croatia

KEYNOTE LECTURES

EDUCATION

ROADS TRAFFIC

ROADS DESIGN

ROADS PAVEMENT

ROADS MAINTENANCE

GEOTECHNICAL WORKS

STRUCTURAL MONITORING

RAILWAYS DESIGN

PERMANENT WAY

RAILWAYS MAINTENANCE

CROSSINGS, JUNCTIONS

RAILWAYS TRAFFIC

VEHICLES

ENVIRONMENTAL

