DEVELOPMENT OF METHODOLOGIES AND MEANS FOR NOISE PROTECTION OF URBAN AREAS – PROJECT DESCRIPTION

Zlatan Šoškić¹, Zoran Petrović¹, Dragan Cvetković² and Srđan Rusov³

¹ University of Kragujevac, Faculty of Mechanical Engineering Kraljevo, Serbia, soskic.z@mfkv.kg.ac.rs
² University of Niš, Faculty of Occupational Safety
³ University of Belgrade, Faculty of Transport and Traffic Engineering

Abstract - The project “Development of methodologies and means for noise protection of urban areas” is national project financed by Ministry of Education and Science of Republic of Serbia with the goal to provide technical support to implementation of noise protection strategy established by Serbian government through a set of laws and regulations. The project comprises three groups of activities: 1) development of methodologies and software support for estimation of exposition to noise 2) development of laboratories for acoustic characterization of objects and 3) design of modular means for noise protection. The project is realized in period 2011–2014 by Serbian universities from Kragujevac, Niš and Belgrade, and with support of Serbian industry and local governments. The paper presents project plan and organization, as well as the performed activities and the obtained results.

1. INTRODUCTION

The last decade of the XX century and the first decade of the XXI century have seen harmonized efforts of policy makers and researchers in European Union with the goal to establish a common strategy for combating noise and to develop means for its implementation. The strategy is expressed through a set of documents based on the European Directive on the Assessment and Management of Environmental Noise or Environmental Noise Directive (2002/49/EC) from June 2002 [1]. Under this directive, as a first step in the strategy, member states were obliged to produce noise maps of the major roads, railways, airports and industrial activity sites as well as of large agglomerations by 30th of June, 2007. Noise maps are intended to describe the environmental noise levels caused by the previously mentioned sources in terms of the harmonized noise indicators \( L_{day} \) and \( L_{night} \). From these noise levels, other indicators such as the total number of seriously annoyed residents may be derived. This information was to be submitted to the European Commission and made public. The next step of the strategy is drafting of Noise Action Plans, sets of measures for managing the noise issues and effects, including the reduction of noise if necessary. The Noise Action Plans are to be based on the noise–mapping results, drawn by competent authorities with consultation of general public on matters of priorities.

The adopted strategy, though, requested research work in order to provide for technical basis for implementation of the strategy. The research work was carried out through series of national and EU projects, like FP5 project “Harmonoise” [2], FP6 project “Imagine” [3] and FP7 project “Silence” [4]. The project "Harmonoise" developed common European methodology for estimation of the influence of noise to human agglomerations and common European reference and engineering models for description of sound propagation. The methodology is applied for development of model for prediction of road and railway traffic noise. The efforts of the project "Harmonoise" are complemented by the research work in the project "Imagine" that, following the same methodology and sound propagation model, improved the existing noise prediction models for road and railway traffic and developed common European models for prediction of influence of aircraft and industrial noise. The main goal of the project "Silence" was development of methodologies for drawing of Noise Action Plans.

As a part of its overall effort to harmonize policies and legislation with EU, Republic of Serbia has established national strategy for noise protection and provided relevant legislative framework consisting of a set of laws and regulations presented in the Table 1. However, implementation of the national strategy requires development of an appropriate institutional and technical infrastructure, which does not exist at the moment: majority of the measures prescribed by the regulations is still not supported by existence of the relevant accredited institutions and research groups, noise protection means available at market and adequate software support. With the aim to solve some of the technical problems connected with the development of the institutional and technical infrastructure, in July 2010 Serbian universities from Kragujevac, Niš and Belgrade proposed to the Serbian Ministry of Education and Science a project entitled “Development of methodologies and means for noise protection of urban areas”. The proposal was accepted in December 2010.

This paper describes the concept of the project and the main results achieved in the period 2011–2012.
Table 1 Serbian legislative framework considering environment noise protection

<table>
<thead>
<tr>
<th>Category</th>
<th>Legal act</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laws</td>
<td>Law on environmental noise protection of Republic of Serbia (Official Gazette of Republic of Serbia , No. 36/2009 and 88/2010)</td>
<td>Relevant for topics of subjects in charge for environment noise protection, means and conditions for environment noise protection, measurement of environmental noise, access to information about noise, surveillance and other topics of relevance for environment and health protection</td>
</tr>
<tr>
<td></td>
<td>Guidelines on conditions and documentation for expert organization for noise measurements (Official Gazette of Republic of Serbia, No. 72/2010)</td>
<td>Determines conditions that an expert organization for noise measurements has to fulfill, but also documentation that has to be submitted with application for authorization.</td>
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PROJECT DESCRIPTION

Goals and objectives

The goal of the project is to provide technical support to implementation of national strategy for protection from environmental noise through provision of:

- Certified facility for characterization of noise sources;
- Development of software support for local noise mapping and modeling;
- Design of modular noise protection means;

This goal is intended to be reached through achievement of the following objectives:

1. Carrying out a study on dominant noise sources in urban areas in Serbia; the study is to provide the basis for further directions of the action in course of the project;
2. Design of the database for description of urban noise sources; the database will be used as the source of data for local noise mapping and modeling;
3. Construction of reverberation chamber and anechoic chamber and accreditation of the research and testing facility;
4. Development of software modules for noise modeling capable of calculation of noise level generated by multiple sources in presence of multiple barriers and in various environments;
5. Study on state–of–the–art of noise protection means, which will be further used as the basis for design of noise protection means;
6. Design of modular barriers for noise protection

Besides, the project intends to further facilitate basic research in the field of applied acoustics through enhancing and stimulating studies in the following research fields:

- Modeling of acoustic fields of noise sources;
- Active noise protection (both construction methods and emission methods)

**Project plan**

The project activities are organized in three workpackages that contain research and development activities, one workpackage that contains promotion activities and one workpackage that contains project management activities.

The first R&D workpackage, entitled "Development of methods for estimation of exposition to noise", gathers activities that are concerned with measurement, mapping and prediction of noise levels in urban areas. The main activities of the workpackage are:

1.1. Study of dominant noise sources in Serbian urban areas
1.2. Design of national database for industrial, traffic and public service noise sources
1.3. Presentation of GIS data in noise maps
1.4. Development of software modules for noise mapping and modeling

The second R&D workpackage, entitled "Development of materials and means for reduction of noise emission", gathers activities concerned with measurement of noise emission of individual noise sources, as well as with active and passive methods for reduction of the emitted noise. The main activities of the workpackage are:

2.1. Study of methods for active noise protection
2.1.1. Study of construction methods for active noise protection
2.1.2. Study of emission methods for active noise protection
2.2. Construction of reverberation chamber and semi–anechoic chamber
2.3. Study of absorption methods and materials for noise protection
2.3.1. Study of noise absorption by plant fields
2.3.2. Study of noise absorption by waste materials
2.3.3. Study of noise absorption by Serbian construction materials

The third R&D workpackage, entitled "Design of means for noise protection", gathers activities concerned with design of modular barriers and other means for protection of urban areas from emitted noise. The main activities of the workpackage are:

1. Study of contemporary concepts in design of noise protection means
2. Conceptual design
3. Design of the selected noise protection solutions
4. Construction and testing of prototypes
5. Design of technologies, auxiliary tools and packages

The three workpackages thus represent a harmonized and complete set of actions with intentions to provide technical means for revealing places with intensive noise exposition, determining the causes of the noise and, according to possibilities, to reduce noise emission or to protect the endangered area from the emitted noise.

Following the policy of the Ministry of Education and Science of Republic of Serbia, the project comprises also intensive project promotion activities, oriented both towards expert and general public. Promotion activities oriented towards expert public include participation in national and international conferences, publication of journal papers and organization of seminars for professionals in field of environment protection. Promotion activities for general public include development of website of the project, information on major project results in media and participation in science popularization events. All the activities are grouped in one very diverse and loosely organized workpackage.

Finally, the project demands organization and control measures, as well as reporting activities, which are gathered in one workpackage dedicated to project management. This workpackage includes weekly activity team meetings, monthly or bi–monthly meetings of teams within research organizations and meetings of the whole project team each six months. According to the rules of Serbian Ministry of Education and Science, two kinds of reports are submitted annually, one concerning research results, and the other concerning financial management topics.

Considering the dependences between the project activities, limitation in human and material resources and conditions posted by Serbian Ministry of Education and Science, the project duration is four years, and it will be carried out in period 1st of January 2011 – 31st of December 2014.

**Organization**

For the achievement of project objectives are engaged available human and material resources. Human resources consist of team of researchers from University of Kragujevac (Faculty of Mechanical Engineering Kraljevo), University of Niš (Faculty of Occupational Safety) and University of Belgrade (Faculty of Traffic Engineering). The researchers provide expertise and experience in following research areas:

- noise and vibration
- measurement techniques
- software development
- project management

The team is organized in three research groups:

- Group for methodologies of noise studies
- Group for design of noise protection means
- Group for software development and support

Group for methodologies of noise studies concerns with development of methodologies for measurement of noise emission, methodologies for modeling of noise propagation and methodologies for estimation of effects of noise exposition in urban areas. The group consists of experts in noise and vibration and it is responsible for activities from
the first and the second workpackage except for the activities 1.2 and 1.4 in the first workpackage.

Group for design of noise protection means concerns with design of noise protection means for active and passive noise protection. It consists of mechanical engineers and is responsible for activities in the third research workpackage.

Group for software development and support concerns with design and implementation of software tools for noise field modeling and noise measurements, with development of databases for noise modeling and project management purposes, as well as with development of the website and other promotion tools. It consists of electrical engineers and is responsible for project activities 1.2 and 1.4 of the first workpackage, as well as activities from workpackages concerned with promotion, dissemination and project management.

The complete team consists at the moment of sixteen researchers. Eleven of them are mechanical engineers (nine experienced researchers and two junior researchers), four are electrical engineers (two experienced and two junior researchers), while one is traffic engineer.

The matrix that shows the dependence between project organization structure and work breakdown structure is shown in the Fig.1.

The direct costs of the project are around 220,000 EUR. The budget breakdown is as follows:
- Personnel costs 140,000 EUR
- Equipment costs 60,000 EUR
- Travel, consumables and other costs 20,000 EUR

The project budget is provided by Ministry of Science of Republic of Serbia (80%), financial contribution of Municipalities of Niš and Kraljevo, as well as by contribution in material and work by companies “ABS Minel” from Belgrade and “Korali” from Kraljevo.

**PROJECT RESULTS**

The project “Development of methodologies and means for urban noise protection” passed through its initial phase in 2011, and in the first half of 2012 are obtained some final and some important intermediate results.

**Workpackage 1: Development of methods for estimation of exposition to noise**

The activity “Study of dominant noise sources in Serbian urban areas” is performed through contacts with local governments (local ecology action teams). They were asked to fulfill a form describing the concepts of noise monitoring including methodology of noise measurements, timing of measurements, selection criteria, number and disposition of measurement points. Besides, the form requested description of results of noise monitoring through rough distribution of measurement results expressed as percentage of measurement points where noise limits are exceeded. Noise monitoring is performed in twenty Serbian cities, and the response is obtained from the four of them, while the data are gathered from the websites of six more cities. The data showed great deal of variety between the methodologies applied in the cities, and the results of the study are presented in this conference [5]. The further work within the activity depends on the activities of Agency for noise protection of Republic of Serbia that still needs to define its policy and role in noise protection.

Additional work on the activity is performed through noise measurements on specific urban objects. For different reasons, the noise measurements were focused on crossroads (with the idea to test different models of crossroad noise) and elementary schools (by request of local governments as project participants). The results obtained in these tasks are presented at this conference [6][7].
The activity “Design of national database for industrial, traffic and public service noise sources” resulted in development of online relational database which is available via internet [8]. The database enables detailed description of point sources and line sources by storing data about sound power, spectra and spatial distribution of emitted noise. For complex noise sources, the database provides possibility for storing mathematical relationships which describe emitted noise. The access to the database data is possible through standard SQL queries, which is suitable for development of software tools and components for noise mapping. Read rights are granted without limitation, whereas rights for writing the data are granted only to developers at the moment. The database has interface in Serbian language. While the database is active, the task of inserting data that describe data sources is still to be performed. However, the task has permanent character, and the manner in which it will be performed remains to be determined. The structure and implementation of the database is described in a paper presented at this conference [9].

Work on the activity “Presentation of GIS data in noise maps” started through a case-study of noise protection of area around major overpass in Kraljevo. While the measurements and calculations of noise field are performed, the task is late because of delay of implementation of GIS in Serbian municipalities.

The activity “Development of software modules for noise mapping and modeling” comprises development of modules for modeling of sound propagation and modules for interfacing the software modules with end users and with GIS data systems. At the moment is finished module for calculation of noise field created by multiple sources and screened by multiple barriers. The noise field may have any shape, and barriers are considered vertical. The sources are considered point-like, and while linear sources may be simulated as series of point-like sources, the module for calculation of noise field with linear noise sources. Present interface is provisional and while it provides complete access to functionality of the noise field modeling module, it is textfile-oriented and not so easy to use.

Workpackage 2: Development of materials and means for reduction of noise emission

The most intensive activity performed in the second workpackage was “Construction of reverberation chamber and semi-anechoic chamber”. The activity comprises extensive work and has several tasks. Faculty of Mechanical Engineering Kraljevo provided the premises for the facility, a large room with volume 198.7 m³, and the largest distance 10.8 m (upper limit for the respective volume is 11.1 m). Three-dimensional model of the room is shown in Fig. 2. The room is adapted by provision of insulation layer on the roof (plywood), walls (plaster) and floor (epoxide). By thin concrete walls the room is separated into control room, reverberation chamber and semi-anechoic chamber. The chambers may be joined through a window that can be up to 3 meters wide and up to 3 meters high. After the adaptation, the walls and roof of the reverberation room are equipped with cork insulation plates and reflection panels. Current activities are concerned with provision of measurement equipment suitable for measurement of sound emission and absorption, which is going to be used in research and development of noise protection means. The tasks of testing and adjustment of the facilities, as well as the task their accreditation, still remain to be performed.

Workpackage 3: Design of means for noise protection

The third research workpackage depends on the activities performed in the second workpackage because serious development of noise protection means is not possible without acoustic research facilities.
However, the preparatory activity "Study of contemporary concepts in design of noise protection means" of the workpackage is finished, and the activity "Conceptual design" is underway. The work was focused on studies of noise barriers and the results are presented at this conference [10] [11].

**Workpackage 4: Promotion and dissemination**

The widest promotion tool of the project is its website [12]. Written in Serbian, it presents basic information about project, list of project activities, list of project results and project news. English version of the project website should have shorter form, and it is not expected to be available this year.

Project results are presented to expert public in form of 10 papers published in international and national journals and 30 articles presented at seven international and one national conference. The project is also presented through invited lecture at seminar "Communication, electronics and information technologies" organized in June 2012 in Bansko (Bulgaria).

The most important dissemination event was seminar on noise protection held on 27th of December 2011 at Faculty of Mechanical Engineering Kraljevo. The seminar was held for young researchers and environment protection specialists from local governments with the following topics:

- Physical, physiological and psychological basis of noise studies,
- Noise measurements and characterization,
- Industrial noise,
- Traffic noise,
- Urban noise modeling.

**CONCLUSION**

The paper presented the goals, concept and organization of the project "Development of methodologies and means for urban noise protection". The project, which started at the beginning of 2011, is closing to the end of the second year of work, and achieved the most important goal of establishing technical basis for design and application of noise protection means. The course of events so far confirmed that the project plan was realistic, so it can be expected that the project will achieve its ultimate goal to support implementation of strategy for reduction of noise pollution in Serbia.