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CONFIGURATION OF MODULAR NOISE BARRIERS

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Abstract - *The preliminary design of modular traffic noise barriers was elaborated within the project TP3702 "Development of methodologies and means of noise protection in urban areas". The paper presents the process of configuring modular barriers, the platform which serves as a base and the fund of available modules. Variations in solutions of noise barriers, such as: variations of size and shape of barriers, variations due to the change of barrier orientation, variations due to terrain configuration as well as the combination of barriers with planting, decorative elements, etc. are particularly emphasized.*

Key words: *configuration, noise barriers, modular type, variations*

1. INTRODUCTION

The National Sustainable Development Strategy [20] adopted in 2008 recognizes that noise is a problem in settled areas in the Republic of Serbia and that it is a risk to population health. It points out all types of traffic and various industrial plants as the main causes of noise in the living environment. The main problems stressed by the National Strategy are:

- the lack of coordination with the EU regulations,
- the non-existence of modern regulations for noise measurement,
- the non-existence of regular noise-level monitoring, except in some large cities,
- the non-existence of plans at any level for solving noise issues,
- the lack of compliance with noise insulation regulations in civil engineering, etc.

The Law on Noise Protection, the Regulation on Noise Pollution Indicators and a series of *Rulebooks and Standards* have been adopted in accordance with the strategy and for the purpose of coordinating the national regulations in the field of noise with the EU legislation.

The dominant source of community noise is road traffic. The noise level produced by road vehicles ranges within 60-90 dB(A) depending on the type and speed of vehicles (Figure 1).

The efforts made by car manufacturers to reduce the noise produced by the driving unit and pneumatics in contact with the base are not enough and therefore it is necessary to use noise barriers in settled areas in order to reduce noise to a satisfactory level.

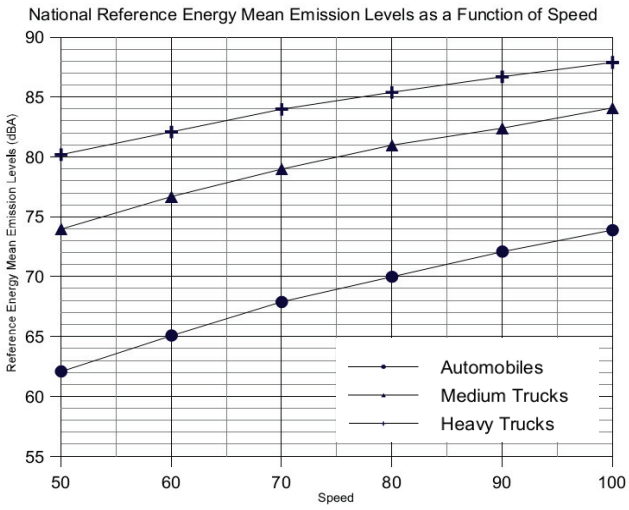


Fig. 1. *Dependence of the traffic noise level on the type and speed of vehicles* [15]

The preliminary design of modular traffic noise barriers was elaborated within the project TP3702 "Development of methodologies and means of noise protection in urban areas". The continuation of the paper presents the process of configuring modular barriers, the platform which serves as a base and the fund of available modules and submodules. Variations in solutions of noise barriers, such as: variations of size and shape of barriers, variations due to the change of barrier orientation, variations due to terrain configuration as well as the combination of barriers with planting, decorative elements, etc. are particularly emphasized.

2. MAIN PRINCIPLES OF NOISE BARRIER DESIGN

2.1 Requirements which should be satisfied in the barrier design process

Noise barrier design is a process which consists of a certain number of logical phases and has the task to achieve the agreed targets. The primary goal is certainly reduction of too much noise by the roads. This acoustic requirement refers to:

- reduction in the noise level at the receiver (outside the road)
- mitigation of the noise level at the noise source (on the road itself).

However, in order to accomplish successful noise barrier design, it is necessary to consider a multitude of other non-acoustic aspects, such as:

- visual attraction (aesthetic appearance),
- compatibility with the local environment,
- safety of drivers in terms of: reduced sight distance, light reflection, safety of a vehicle in collision with a barrier, etc.
- safety of animals living in the habitat where barriers are installed (visible to birds, holes so that smaller animals may pass through, etc.),
- ecological (preservation of animal habitats and local hydrology, toxicity of barrier materials, etc.),
- barrier loading (self-weight, wind gusts, snow, vibrations due to traffic, etc.),
- configuration and structure of the terrain,
- producibility of manufacture and mounting,
- easy maintenance (fast and easy replacement of modules, possibility of cleaning, access to the barrier, etc.),
- costs of manufacture, mounting and maintenance,
- product life (protection from vehicle impact, resistance to chemical influences, resistance to frost, fire, UV radiation, humidity, etc.),
- possibility of recycling after the expiration of the period of utilisation, etc.

A successful noise reduction system can be realized only by applying a multidisciplinary approach in the design process. In order to achieve the project goals, it is necessary to coordinate the work of mechanical and civil engineers, traffic engineers, acoustic engineers, architects, etc. The results should be the noise barriers which fit in the existing environment so that they could be accepted by the local community.

2.2 Modular structuring of products

The use of a modular structure results in a product which is composed of modules that are possible to replace and whose geometrical values or functions can be changed for the purpose of obtaining a sufficient number of different variants. The advantages of application of a modular structure in the process of product design and manufacture, both for the manufacturer and the user, are as follows [3]:

- a large number of product variants realized by a combination of modules,
- the possibility of module replacement,
- a lower price of product variants by using the advantage of serial production of individual modules,
- shortened time for launching a product on the market,
- simplified maintenance,
- possible disassembling of the product at the end of its life cycle.

Modular construction of barriers is a system of construction by means of industrially manufactured elements that are assembled *in situ*. Individual modules (barrier wall, support structure and end profiles) are completely manufactured in the factory, they are then transported to the site where they are assembled into a barrier.

The main modules of a barrier can be:

1. Foundation
2. Barrier wall
3. End profiles
4. Support structure
5. Barrier top

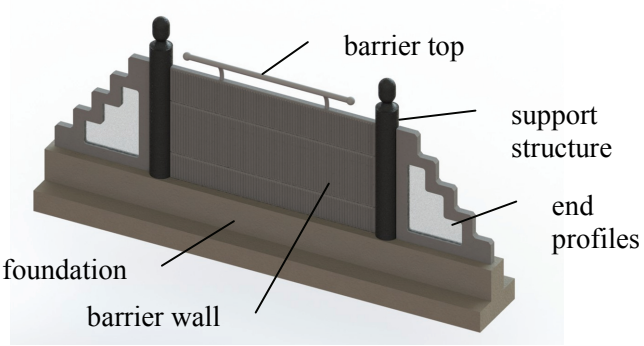


Fig. 2 *Main modules of a traffic noise barrier*

2.3 The product platform and the product family

The product platform represents a set of guidelines that allow a company to develop a sufficient number of product variants aiming at satisfying its customers' needs. The product platform covers [3]:

- a set of main physical components, i.e. modules,
- a set of rules and relations by means of which it is possible to combine product variants,
- a set of available technological possibilities which can be applied in the domain of production,
- a set of employees and their relationships – teams, mutual relationships within the team members and relationships between the teams themselves,
- a set of skills – design knowledge, technology, mathematical models and testing methods, etc.

Product variants offered by a company to the market for the purpose of satisfying individual needs of customers, which is accomplished with the application of a modular structure and the product platform, represent **a product family.** The relation between the modular structure, the product platform and the product family is presented in Figure 3.

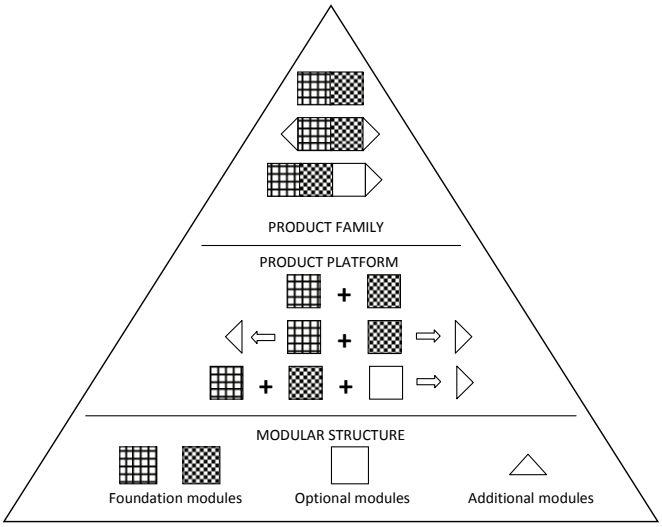


Fig. 3 – *Relation between the modular structure, the product platform and the product family* [3]

3. CONFIGURATION OF MODULAR NOISE BARRIERS

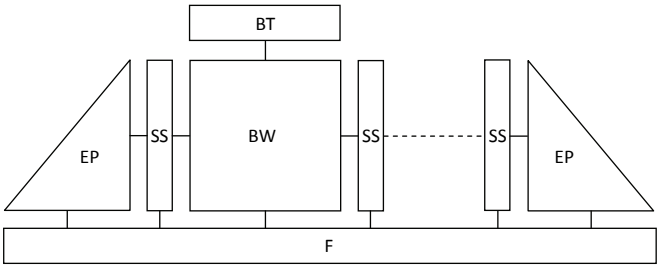
The life of modern products is increasingly shorter, products are more complex, there is a requirement for an increasingly large number of product variants and the shorter total time necessary for launching a product on the market. In addition, the pressure both by the customers and the competition is increased, so that nowadays there are product variants on the market that are more adapted to individual requirements of customers. In order to have a competitive modern company on the market, it is necessary for it to be capable of developing products, within a short period of time, that fulfil the requirements of individual customers. The problem of adapting products to the requirements of customers is solved by developing *configurable products*.

The process of configuring products is an activity that allows determination of the structure of a product variant - out of an available set of modules - which is adapted to the requirements of the customer but still respecting the rules and restrictions set by the product structure.

The result of a configuration process is not always only one configuration because there can be several of them. A configuration process is also an iterative procedure so that it is often necessary to repeat the process several times until the configuration which entirely satisfies all the requirements is obtained. Depending on the requirements, a configuration process can but does not have to find the appropriate configuration, i.e. it may happen that no configuration satisfies the requirements.

The process of forming (configuring) a modular noise barrier (Figure 4) is as follows:

- the foundation which is cast in situ is formed first,
- the support posts are then fixed to the foundation,
- the panels which form the barrier wall are inserted between the support posts,
- the barrier top is fixed to the barrier wall if it is foreseen by the requirement,
- if necessary, the end profiles are placed at the beginning and at the end of the protective field,
- with large spans, it is often necessary to add supports.



Legend: F – foundation
EP – end profile
SS – support structure
BW – barrier wall
BT – barrier top

Fig. 4 – *Scheme of the procedure of configuring a modular noise barrier*

The available fund of modules used for configuration of noise barriers is presented in Figure 5.

4. VARIATIONS IN THE CONFIGURATION PROCESS

Depending on the acoustic and non-acoustic requirements and the configuration of the terrain where noise barriers should be installed, the process of configuring a noise barrier should provide a multitude of different variants and combinations which are presented in continuation.

4.1 Variations of the angle and shape of the barrier profile

Acoustic requirements, requirements with respect to sight distance, specific loads which the barrier is exposed to, etc. often require different shapes of profiles that are realized by a combination of the fund of modules of the support structure and the fund of modules which form the barrier wall (Fig. 6).

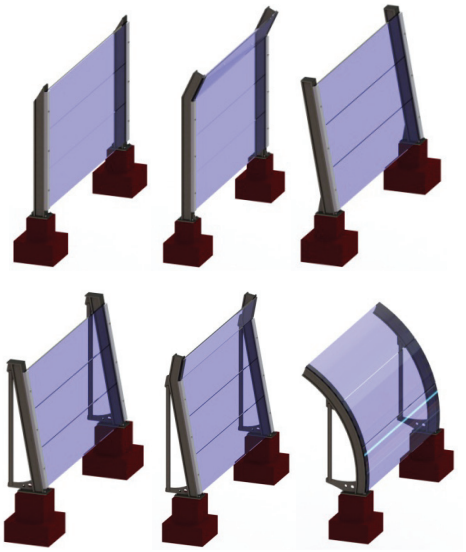


Fig. 6 – *Variations of the angle and shape of the barrier profile*

4.2 Variations of the shape of the support structure depending on the barrier height

Depending on the shape of the barrier profile and its height, especially in the conditions when the barrier is exposed to specific loading such as strong gusts of wind, it is necessary to have an available fund of modules of the support structure that will satisfy these conditions.

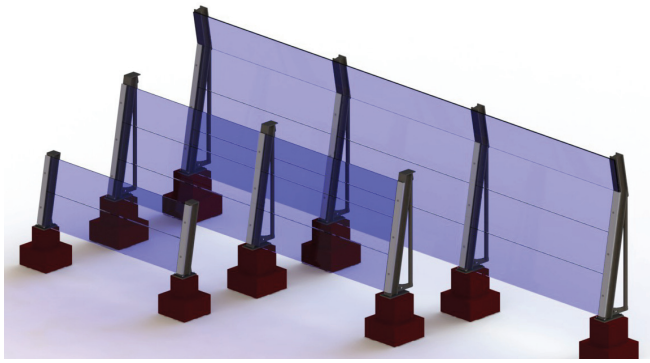


Fig. 7 – *Variations of the shape of the support structure depending on the barrier height*

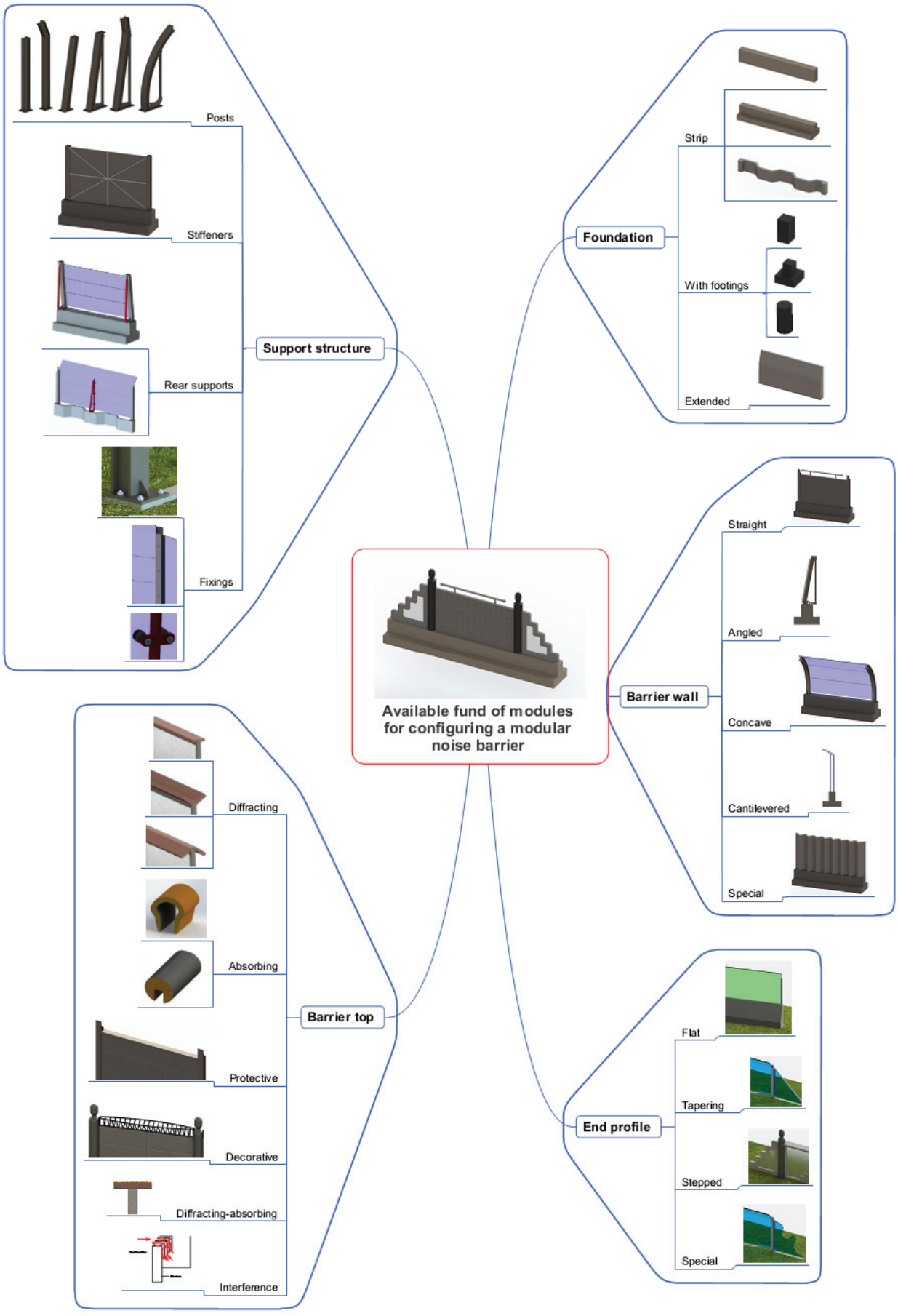


Fig 5 *Available fund of modules for configuring a modular noise barrier*

4.3 Variations due to the change of noise barrier orientation

In suburban areas, in order to accomplish a visual relation between the community and the barrier, it is necessary to integrate barriers into the existing natural environment. Therefore, barriers in these areas are not rectilinear, in a line; their orientation changes and combines with various planting. In that case, it is necessary to have an available fund of different shapes of support posts that can satisfy this requirement.

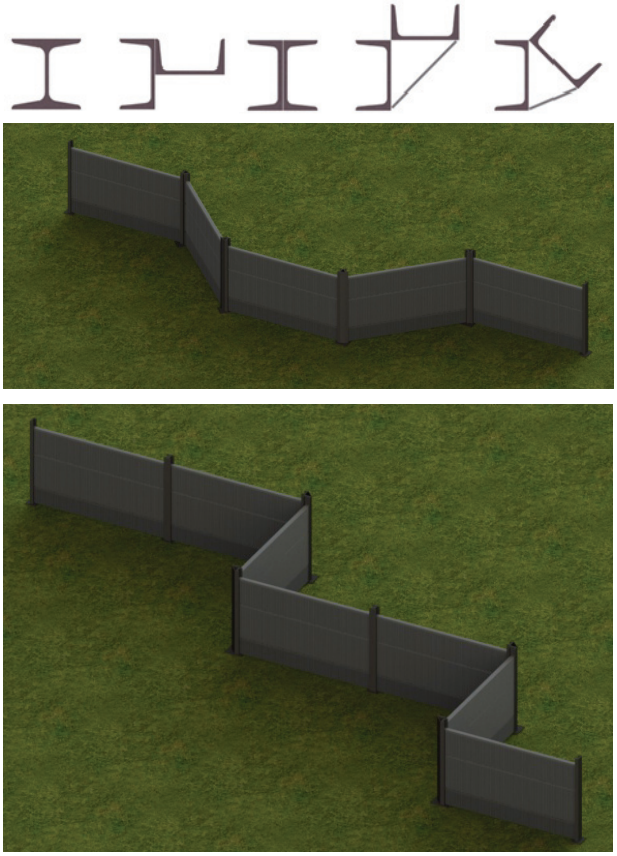


Fig. 8 – *Variations due to the change of noise barrier orientation*

4.4 Variations due to terrain configuration

The terrain where barriers are placed most frequently consists of a lot of rises and falls. If terrain slopes are not steep, this condition can be fulfilled by varying the dimensions of the support posts, i.e. the support structure. If slopes are steep, it is also necessary to have a fund of special modules for creating the barrier wall which do not have a rectangular shape.

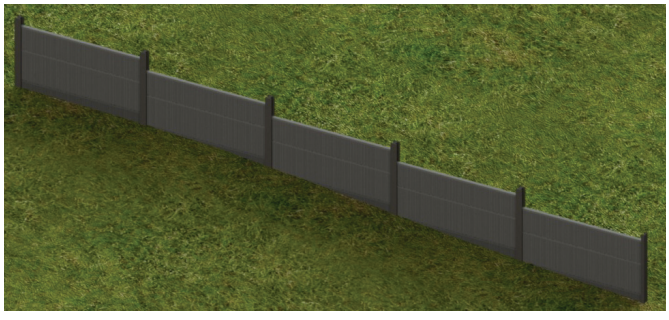


Fig. 9 – *Variations due to terrain configuration*

4.5 Combination of different types of panels for creation of a noise barrier

Different types of panels for the barrier wall are most often combined for the purpose of integration of a barrier in the surroundings and its visual attraction. In order to increase the visibility, i.e. sight distance, transparent and non-transparent panels are frequently combined (Figure 9).

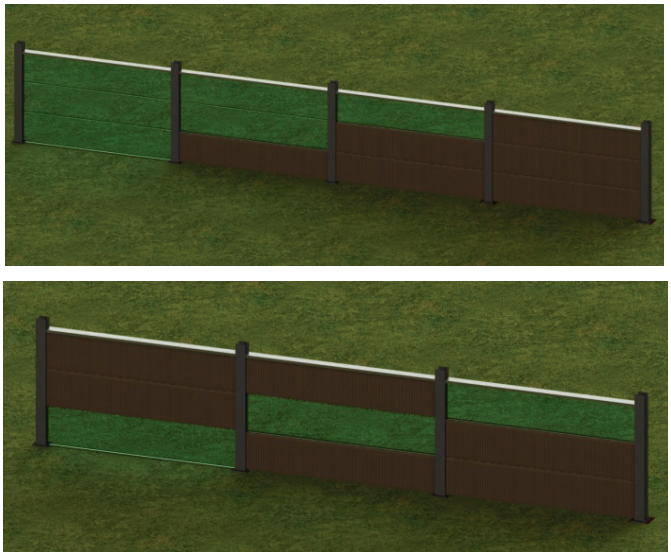


Figure 10 – *Combination of different types of panels for creation of a noise barrier*

4.6 Combination of the barrier with decorative elements

The character and appearance of an urban area should also be reflected in the noise barriers that are installed there as well as in the selection of materials for them. It is also the chance for architects and artists to leave something by which they could be recognized, so it is not often a case that one of the requirements is a special decorative module mounted on the barrier wall or artistic painting of barrier walls.

Fig. 11 – *Combination of the barrier with decorative elements*

4.7 Combination of barriers with planting

The rural environment is characterized by open space, natural trees and bushes. Artifical materials used for barriers will certainly be in contrast with this environment. Therefore, instead of barriers, natural obstacles in the form of earth mounds are usually made in rural areas, and when it is necessary to install barriers, they are usually combined with natural planting whose task is to conceal their visibility.

Fig. 12 – *Combination of barriers with planting* [2]

5. CONCLUSION

Development of *configurable products* based on a modular structure of products is nowadays used as one of the main manners to solve the problem of adapting products to individual requirements of users. Although the products formed in this way are predefined, for the purpose of satisfying a wider range of customers' requirements the market is offered a considerably larger number of product variants with a relatively small number of components (modules), and the period for appearing of a product on the market is considerably shorter.

The project TP37020 has been dealing, to a great extent, with development of configurable traffic noise barriers. The final result of the project should be new technical solutions which will be offered to domestic companies as a new production programme or as an addition to the existing production programme. It is a chance for employing domestic industrial capacities and significant money-saving because the price of a noise barrier in the European Community, depending on its characteristic, size, etc. is around 1,000,000€ per kilometer.

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REFERENCES

[1] M.Praščević, D.Cvetković: Environmental Noise, University of Niš, Fakultet zaštite na radu, Niš, 2005.

[2] B. Kotzen and C. English, *Environmental Noise Barriers, A guide to their acoustic and visual design*, Second edition, Taylor & Francis e-Library, London and New York, 2009.

[3] D. Marjanović: *Sustav za konfiguriranje proizvoda modularne arhitekture*, magistarski rad, Sveučilište u Zagrebu, Fakultet strojarstva i brodogradnje, Zagreb 2003.

[4] G.G. Fleming, H.S. Knauer, C.S.Y. Lee, S. Pedersen: *Noise Barrier Design Handbook, Highway Traffic Noise*, http://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/design/index.cfm

[5] M. Kolarević, Z. Šoškić, Z. Petrović, B. Radičević:*Noise Protection In Urban Environment-Description Of A Project*, Mechanics, Transport, Communications, Academic journal,Todor Kableshkov University of Transport,Sofia, ISSN 1312-3823, issue 3/2011, pp.IV-69-IV-78.

[6] R. E. Klingner, M. T. McNerney, I. Busch-Vishniac: *Design Guide For Highway Noise Barriers*, Research Report 0-1471-4, Center for Transportation Research The University of Texas at Austin, November 2003

[7] H. Knauer, S. Pedersen: *FHWA Highway Construction Noise Handbook*, Highway Traffic Noise, http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook00.cfm#ack

[8] R. F. Blum: *A Guide to Visual Quality in Noise Barrier Design*, Highway Traffic Noise, http://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/visql/acknowledge.cfm

[9] *Guidelines on Design of Noise Barriers*, Environmental Protection Department and Highways Department Government of the Hong Kong SAR, Second Issue, January 2003

[10] *Cutting down noise with precast concrete and masonry barriers,* British Precast , 2005, http://www.britishprecast.org/documents/CuttingDownNoise.pdf

[11] B. Berglund, T. Lindvall, D. H. Schwela (editors). *Guideli-nes for community noise. WHO. World Health Organization 1999. www.who.int/docstore/peh/noise/guidelines2.html*

[12] A. Zlatković, *Analysis of railway vehicles noise management,* Master thesis, Faculty of Traffic Engineering, Belgrade, 2010.

[13] *Design Guide For Environmental Barrier,* Volume 10 Section 5, Part 1 HA 65/94, 2001

[14] *Environmental Barriers: Technical Requirements,* Volume 10 Section 5, Part 2 HA 66/95, *2001.*

[15] *Highway Traffic Noise Analysis And Abatement Policy And Guidance* by U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning Noise and Air Quality Branch, Washington, D.C., June 1995

[16] *Directive 2002/49/EC* of The European Parliament and The Council of The European Union

[17] Serbian standard ISO 1996-1,2, Official Gazette of Republic of Serbia,

[18] Law on environmental noise protection of Republic of Serbia, Official Gazette of Republic of Serbia, No. 36/2009

[19] Regulation on noise indicators, limiting values and methods for estimation of noise indicators, annoyance and detrimental effects of noise, Official Gazette of Republic of Serbia, No. 75/2010

[20] National strategy of sustainable development, Government of Republic of Serbia, Belgrade 2008

[21] http://www.mfkv.rs/urbanoise