ANALELE UNIVERSITĂȚII
"EFTIMIE MURGU" REȘIȚA
ANUL XVI, NR. 1, 2009, ISSN 1453 - 7397

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Solutions to Mitigate Vibrations and Noise Produced by Tramways (State of Art)

Vibrations and noises produced by daily human activities represent a major issue of nowadays, having a negative impact both on environment and on people. These negative effects occur with the human evolution and development and remain a problem that needs to be solved. The paper describes a part of the methods used on vibrations and noise damping, caused by road traffic, with reference in particular to tramways.

Keywords: *vibration, noise, insulation, tramway.*

1. Introduction

The accelerated growth of road traffic and the intensive development of technology and industry determine vibration and noise pollution to become a major problem as regards the impact on urban infrastructure and on human factor as well.

It is well known that noise is transmitted through a structure via vibrations, the noise, on one hand, causes the structure to vibrate and, on the other hand, the vibration becomes a secondary source of noise.

The negative effects of vibrations resulting from the continuous traffic, both private and public, are increasingly visible in internal and external structure of buildings and structure of tracks (roads), especially in crowded perimeters of the city, and the noise resulted from it affects more and more social comfort.

However it is obvious the expediency of public transportation, of tramway with predilection, particularly in urban areas with a high concentration of population, thus reducing road traffic significantly. Also we must take into consideration that the tram has a capacity to transport more people compared to other vehicles, is environmentally clean, reliable, has its own track and uses electricity less expensive than diesel, and the lifetime of a tram is much higher.

Although it is advantageous in this regard, the issue of vibrations and noise which the tramway produces can not be ignored. In terms of replacing trams opinions are divided, but to dispense with this mode of public transport and purchase more buses in their place is not a solution, in conditions in which we attempt at global level to reduce atmospheric pollution. From long-term costs point of view, dismantling the network of tram railway and replace it with another type of vehicle would amount to modernization of tram itself and of the track used for them.

2. Scientific background

There have been done some research to find modern solutions in order to reduce vibrations and noise pollution produced by trams on the route source - destination.

During the period of 2005 - 2007, RESEARCH INSTITUTE FOR TECHNOLOGY AND EQUIPMENT IN BUILDINGS - ICECON S.A. developed the project "Method and system for evaluating, monitoring and reduction of the vibrations level transmitted to the human factor", led by project director Aurelia Mihalcea [3]. The project was part of the research program PNCDI (national program of research, development and innovation). The relevance of the project is based on an innovative method of monitoring and evaluation systems and devices for isolating and protecting the human factor against vibration and shock caused by various technological equipments. It is required monitoring antivibratile systems subject of environmental factors and various applications in view of desired optimal functioning of these systems. Thus these devices can increase in performance and it can intervene in time in the event of a failure.

The Autonomous Administration of Transport Ploieşti proposed in 2005 a series of solutions to improve infrastructure of tram runways, reducing vibration and noise produced by them. Solutions require changes to the construction of tram tracks as follows:

The rail is continuously welded on concrete sleepers, with elastic grip, on a multilayered ballast bed, and is provided with layers for water disposal and layers for absorption of vibrations;

The rail is continuously welded on concrete longrine, with elastic grip, on a multilayered ballast bed, being actually embedded in the concrete plate and provided with elastic elements, made out of rubber, between rail and plate.

In April 2006 the City hall of Cluj - Napoca had in plan for 2007 the modernization of tram route Manaştur - CUG, through a project funded by the EU, which followed the reduction of vibrations and shocks with 40%, of noise with 45% and to increase the speed of traffic [7]. After the feasibility study carried out was considered that the optimal solutions are building a tramway that has the channel rail with reinforced concrete slab 20 cm thick to ensure the strength, stability and sustainability of the rail track for a period of 25 year long, applying to the rail the system ISOLast based on elastic suspension and continuous electric isolation to miti-

gate shocks, with the advantage that subsequent repairs will be made directly to the rail and will not be necessary related work.

Another insulating solution of vibration and noise was given by Technical University of Constructions Bucharest under the coordination of Lecturer Dr. Engineer George Stoicescu, in partnership with the Research Institute of Electrical Engineering, Institute of Macromolecular Chemistry Petru Poni, Center for Research, Design Plastics Processing - Ceproplast S.A. Iaşi and S.C. Incubus Consulting S.R.L.

They conducted the research project "New materials and applications for the modernization of transport infrastructure in order to reduce the vibration and noise on the tracks and underground terane" during 2006 - 2008. The project aimed to reduce the level of vibration and noise to the network of tram lines (and not only) by applying an elastic system to the wheel – rail system.

Figure 1. System of fixing rails

Figure 2. Insulation model of a tram rail

In the research there have been identified physical models, experimental ones, using elastic plates made out of polyurethane material with a high capacity to absorb vibration and with a long life in natural climate conditions. The elastic plates were inserted between the network elements of the railway: rail, plate holder, traverse, slab, ballast, concrete platform. The resilient plate of PR3 type will be positioned under the rail' s sole and the resilient plate of PR2 type will be positioned between the metal support plate and reinforced concrete cross [2].

Figure 3. Elastic plate model of PR2 type

Figure 4. Elastic plate model of PR3 type

Insulation solutions determined in this project are in accordance with EU requirements on environmental and urban policies. The results obtained from this research have been reducing the level of vibration / noise up to 10 dB considered for each elastic floor inlaid in the railway.

A solution used to reduce the vibrations / noise produced by trams, already implemented and tested in Norway, Sweden, Poland, Germany, is "RockBallast 3515" of RockDelta Company. "RockBallast 3515" method is designed to reduce ground-borne and structure-borne vibration from rail transport systems. This vibration insulation solution consists of a resilient mat manufactured from stone wool and preserved from ground and ballast damage by a protective layer consisting of a composite material produced by Terram Limited Company, comprising two membranes, a non-woven geo - textile one and a load-distributing core one [5]. The resilient mat and the protective layer are placed under a ballast mat.

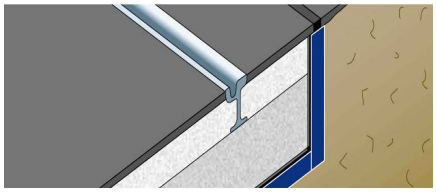

Figure 3. Floating concrete solution

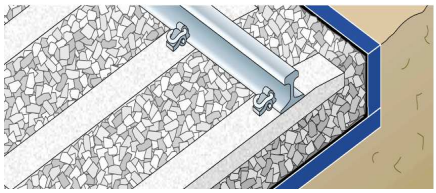

Figure 4. Sub ballast mat solution

Also designed by RockDelta Company, "RockXolid 50" is another method used to mitigate vibrations, based on steel springs, a 50 mm stone wool layer and reinforced concrete. The "RockXolid 50" is laid under a 500 mm concrete slab along the tramway track. Its thickness decreases, and consequently its rigidity increases, gradually from 150 mm to 50 mm, changing the system resonance frequency incrementally from 5 Hz to approximately 20 Hz [6].

The solutions designed by RockDelta are meant to attenuate vibrations and noise produced by tramways, under ideal conditions, with up to 25 dB, though the results obtained in Sweden, where RockBallast was inserted, were the reduction of vibrations with 14 dB, which was a great realizations regarding the environmental conditions.

The methods of vibrations and noise insulation presented so far are applicable at source. There are ways to mitigate vibration and noise level at destination, such as buildings.

Regarding the insulation of vibrations and noise at destination, S.C. ICECON S.A., in collaboration with INCAS institute, Polytechnic University of Bucharest, "Transylvania" University of Braşov and University of Piteşti, comes with an innovative solution that involves the use of sound - absorbent panels.

This system, described in the project "SIPCAS" [8], consists of sandwich - composite panels that attenuates noise from the traffic caused by road vehicles, trams, trains, are simple in terms of constructive and can be easily mounted, have

low mass, are resistant to environmental factors, inflection, astriction, impact and corrosion, are fireproof and are not hydroscopic.

The parts constituting the sandwich - composite panel that are included in the sound-absorbent system are the working sides and lateral sides made of reinforced polymer composite materials and the core made of MOGAPAN honeycomb structures - a material with a large capacity attenuation of sound. This vibration/noise damping method at source implies fixing the panels on the building's walls. Level of vibration insulation depends on thickness of the panel. Thereby, for a thickness of 20 mm the insulation index equals 30 dB, for a 40 mm thick panel the insulation index equals 45 dB and for 60 mm thickness the insulation index equals 60 dB [1].

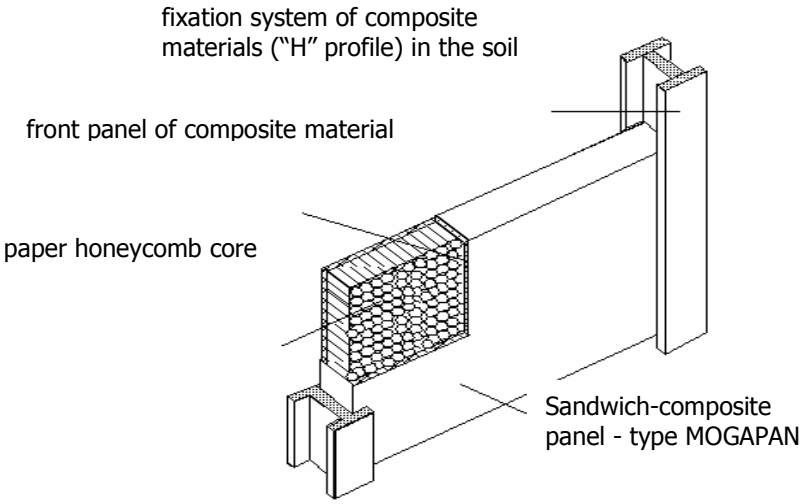

Figure 5. Constructive principle of a system for reducing noise from urban traffic

The sandwich-composite panels of MOGAPAN type can be implemented on the course of vibration / noise transmission, between source and destination. The fixing systems in soil or of roadside obstructions from the road edge have the shape of an "H" profile and are made of reinforced polymer composite materials.

3. Conclusion

The solutions for vibration and noise damping described in this paper can be considered optimal from different points of view. From each one of them had result a significant progress in redemption of vibration / noise level, considering the negative effects that these can produce over environment and over human factor.

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