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URBAN POLLUTION ISSUES GENERATED BY TRAMS TRAFFIC

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ABSTRACT

The modern society development involves new and diverse issues considering urban environmental pollution. Traffic generated sound and vibration are two up-to-date urban environmental pollution causes besides air and water pollution ones. Public transportation in metropolitan areas is a major and constant all levels environmental pollution cause. Electric engines as an alternative to internal combustion ones could reduce the air pollution caused by urban public transportation. The tram network is an important element of this approach even if a poor condition of tram network elements could be a major cause of sound and vibration environmental pollution. This research paper is a study of a particular case considering the vibration level transmitted to a building close to tram network in the town of Braila City.

KEYWORDS: urban, pollution, vibration, tram

In this century of speed, the tram, as a part of public transportation, generates few environmental and economic problems. For instance, it requires expensive runways and power networks, low speed and a high weight. For example, the Imperio model produced by SC Astra vagoane Arad, Romania, can be purchased for 1.7 million Euros despite the above mentioned drawbacks as well as acoustic and vibration pollution.

Having said the low maintenance costs and high exploitation durability, this type of public transportation does not pollute the environment as much as internal combustion engines do.

Due to the increase of registered vehicles, the use of trams has become a compulsory necessity regarding the pollution of the atmosphere.

In Romania, immediately after the early beginning of the 2008 financial crisis, the car park has been keeping its increasing tendency, but at a slower rate.

As a result, between 2010 and 2014, it increased by 777 547 vehicles.

The city of Braila had its auto park expanded by a number of 13079 cars, in the 2010-2014 period, reported to the 180 000 inhabitants. A natural consequence of the increased number of vehicles is the pollution emphases caused by the gases released by the internal combustion engine [1].

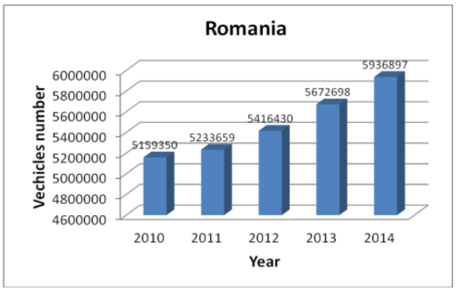


Fig. 1. *Evolution of the number of vehicles in Romania*

Even if some vehicles are provided with catalysts, they start functioning at an optimum level after a certain time, when they reach at least 400 ºC, which is equal to driving for nearly 10 km.

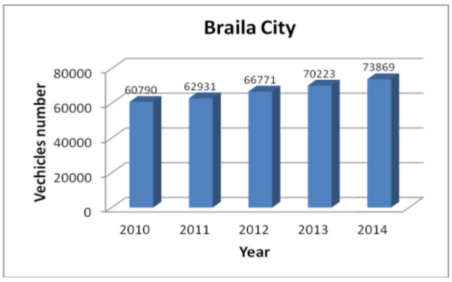


Fig. 2. *Evolution of the number of vehicles in Braila City*

2. The effects of the trams on buildings and their inhabitants

Usually, when both the driving way and the tram do not have defects of intense usage or accident, this type of transportation must not produce polluting vibrations. Otherwise, the vibrations generated by the functioning tram may have undesirable effects on nearby buildings, their tenants and technical equipment, as well. As for the buildings placed in the propagated vibration area, it can result in the defacement of the construction elements, such as unequal settlements or even a reduced level of structure stability. The same phenomenon may induce to the inhabitants of those buildings tiredness which leads to various pathologies or may have bad effects on the proper functioning of electronic equipment which require a high performance level [2, 3, 4]. There are legal notices which enforce the maximum values to vibration parameters for the nearby buildings, to avoid negative effects produced by trams’ traffic.

In Romania, the laws and regulations in the field consider the SR12025-2-94 as the standard, which mention the legal limit for vibrations generated by the road traffic and transmitted to buildings or to certain parts of them.

2.1. Building presentation

For inhabited buildings or socio-cultural ones, using them properly can be reached by providing structural entirety and inside comfort. The assessment of these two desires can be achieved by predictive maintenance activities which consists of periodic checks of the vibration parameter values for buildings in imposed limits by the regulations.

Fig. 3. *The building located near tram line: 1 - residential building; 2 - road* [5]

Through the current study, the vibration parameters which are generated by the trams' traffic transmitted to a block of flats from Brăila city were quantified experimentally, with a view to examining these values in order to compare them to the permitted quota.

The building monitored throughout this experimental study is placed on the Independence Boulevard in Braila, at a 9 meters’ distance from the drive way of the tram of the Radu Negru-Vidin route.

The block of flats is built on two floors, semi-basement and a story, its structure being made out of brick.

2.2. The system of measurement devices

The assessment of the vibration level originated in the trams' traffic was realized using the following equipment:

- acquisition and processing system with PCeight-channel acquisition board HARMONIE Octav - Sinus Messtechnik GmbH;
- two piezoelectric seismic accelerometers, type 393B04 - PCB;
- required connectors.

a. floor b. semibasement

Fig. 4. *Accelerometer location on the first and second floor, on the external wall, parallel to the tram rails*

Experimental measurements were carried out with two vertically placed accelerometers, at the same time, on different building elements, as follows:

- simultaneous positioning on two levels;
- two floors simultaneous positioning on the wall, parallel to the road;
- two floors simultaneous positioning on the wall, perpendicular to the road;

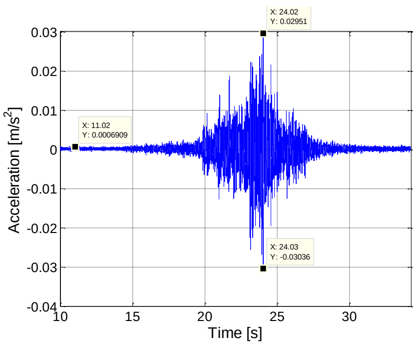
a. floor b. semibasement

Fig. 5. *Accelerometer location on the first and second floor*

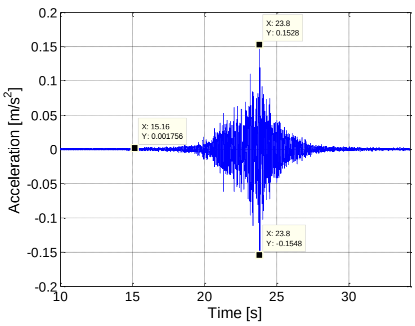
a. floor b. semibasement

Fig. 6. *Accelerometer location on the first and second floor, on the external wall, perpendicular to the tram rails*

In order to determine the level of vibration absorbed by each building element, seven sets of signal acceleration were recorded and processed using the MATLAB R14, [6, 7]. A spectral analysis of the acquired acceleration signals was performed to identify the significant frequencies and to determine their parameter levels.

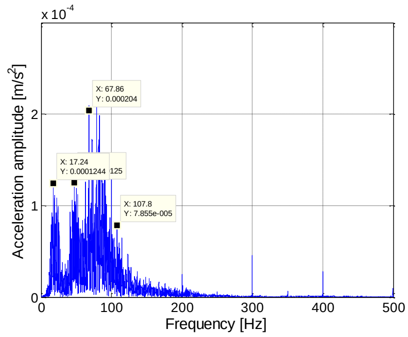


a. floor

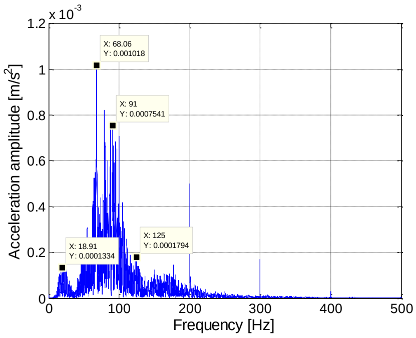


b. semibasement

Fig. 7. *Acceleration signals from exterior wall accelerometer, parallel to the tram line*

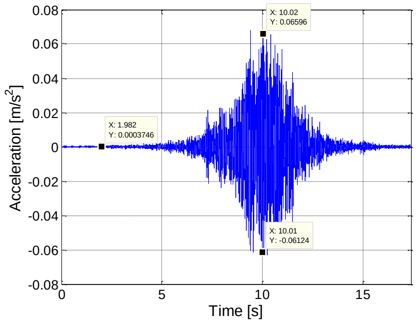


a. floor

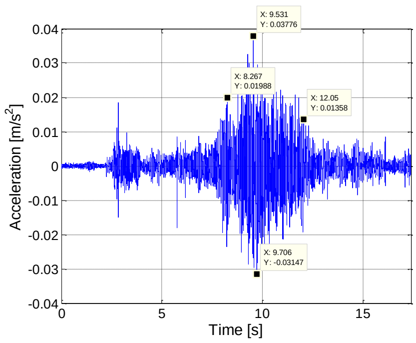


b. semibasement

Fig. 8. *Graphic presentation of the spectral accelerometer acceleration signals from exterior wall, parallel to the tram line*

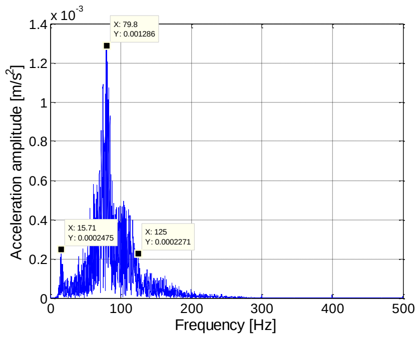


a. floor

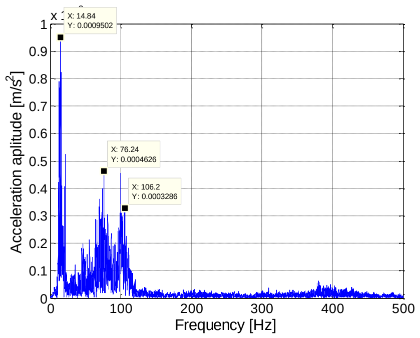


b. semibasement

Fig. 9. *Acceleration signals considering accelerometer floor location*

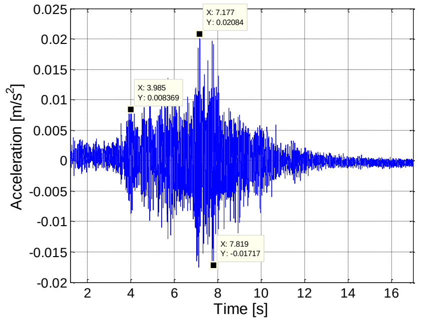


a. floor

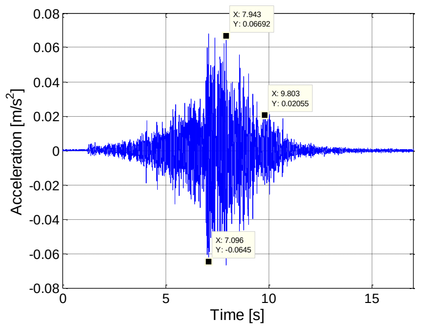


b. semibasement

Fig. 10. *Graphic presentation of the spectral acceleration for accelerometer location on floors*

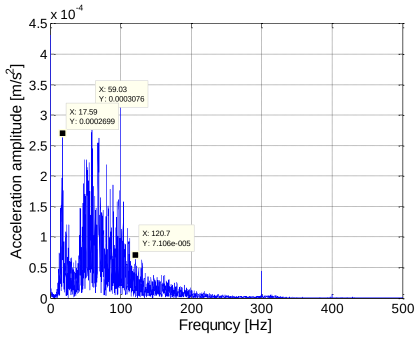


a. floor

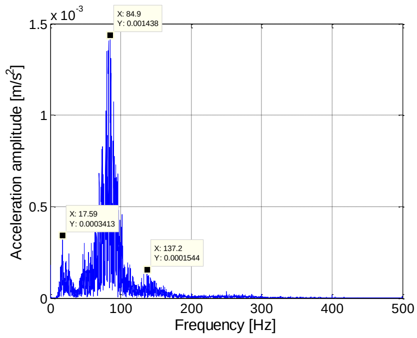


b. semibasement

Fig. 11. *Accelerometer acceleration signals from exterior wall, perpendicular to the tram line*



a. floor



b. semibasement

Fig. 12. *Graphic presentation of the spectral acceleration signals for accelerometers on the outer wall, perpendicular to the tram line*

3.3. Final evaluation

To assess the harmfulness of the tram traffic induced vibrations, the following parameters were calculated: the vibration intensity, the acceleration level and vibration strength [3, 8, 9].

To assess the comfort of the building occupants, the vibration acceleration values (according to SR 12025/94) were used for vibration levels being reported to 80 equal curve physiologically tolerable level (A_V^Z), corresponding to residential buildings. According to Table 1, some values (red) stand out. They are located above the curve 80, especially for low frequencies vibration, but under the 92 curve, corresponding to commercial buildings.

In order to evaluate the effect of vibration on the structure of the building, the vibration strength levels were compared to allowable values recommended in the literature [2]. One single value, which is classified as a mild tremor, exceeded the vibration strength levels for the wall that paralleled the tram rails.

Table 1. *Vibration parameters on residential buildings*

Accelerometers positioned	Recording	Level	Acceleration peak [m/s^2]	Frequency [Hz]	Vibration intensity [cm^2/s^3]	Acceleration level [dB]	Vibration strength [vibrar]
A.Accelerometer location on the first and second floor, on the external wall, parallel to the tram rails	**Recording 2**	semibasement	0.016	15	0.17	84.08	2.32
		floor	0.091	81	1.02	99.18	10.09
	Recording 3	semibasement	0.029	67	0.12	89.24	0.98
		floor	0.15	66	3.40	103.52	15.32
	Recording 4	semibasement	0.02	14	0.28	86.02	4.55
		floor	0.077	66	0.89	97.72	9.53
B.Accelerometer location on the first and second floors	**Recording 5**	semibasement	0.065	79.8	0.52	96.25	7.23
		floor	0.038	14	1.03	91.59	10.13
	Recording 6	semibasement	0.044	79.7	0.24	92.86	3.85
		floor	0.03	14	0.64	89.54	8.08
C.Accelerometer location on the first and second floors, on the external wall, perpendicular to the tram rails	**Recording 7**	semibasement	0.013	16	0.10	82.27	0.23
		floor	0.029	63	0.13	89.24	1.25
	Recording 8	semibasement	0.02	17	0.23	86.02	3.71
		floor	0.066	64	0.68	96.39	8.32

4. Conclusions and outlook

The assessment of the tram traffic vibration level on residential buildings is a necessity imposed by the requirements of indoor comfort for residents and ensures the structural integrity of the building.

Experimental measurements showed an excess of vibration level that did not affect the residents. There was a single case of vibration which can be classified as a light one. We can consider that currently the vibrations are not a major stress factor for inhabitants or an imminent threat to the structural integrity of the building, due to reduced traffic (one tram at every 10 or 15 minutes).

The application of predictive maintenance has to be considered. It requires regular assessment of the level of trams traffic vibration on buildings as a method of evaluation for normal operation and tread.

Several solutions can be implemented to reduce or even eliminate the effects of vibration from trams traffic on nearby buildings:

- rehabilitation by replacing the tread rubber damping elements installed under tram tracks. The viscoelastic proprieties of the rubber vary with time. After 15 years, the rubber „is getting old", losing its initial properties;
- replacing the old trams;
- insulating the base of nearby buildings. This is an approach for new buildings (too expensive for old ones).

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