Noise and vibrations at tram track intersection

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In urban areas noise and vibration due to public traffic diminish the quality of life. In Zagreb, tram traffic is the most important form of public transport. Tram network has 120 km of the tracks and 190 trams are used for passengers transport every day. In the movement of the vehicle over track, the interaction between the wheel and track plays the most important role in the field of noise and vibrations. The increasing of noise and vibrations are particularly emphasized at track intersection where a given number of track switches and crossings are installed. This paper presents an experimental study of noise and ground vibrations through the passage of three types of tram vehicles. The measurements were done on the tram intersection with the highest traffic volume in Zagreb’s tram network. Two types of track construction were analyzed, discrete and continuous rail fastening system. During the track reconstruction at this intersection, the existing discrete rail fastening system was replaced with a continuous. Because of that, the measurements were carried before and after reconstruction at the same test points. Test results have showed significant reductions of noise and vibrations at track intersection in the case of continuous rail installation.

1 Introduction

In urban communities, traffic on rails has great advantages in relation to the road traffic, especially if separate corridors are ensured, whereby traffic on rails is separated from the road traffic. Without regard whether the rails are executed in the same level or on an object or in tunnels, special attention must be paid to vibrations, which occur because of vehicle movement on the rails. An increased level of noise and an increased intensity of vibrations are especially expressed on those parts of the rail network, where tracks are situated immediately near the buildings [1]. Additional increased noise and vibrations are especially expressed on places of tram crossings, where a certain number of switches and crossings are built in. In Figure 1, a regular tram crossing is shown, paved by concrete slabs, which is the usual manner of pavement in the city of Zagreb.

Especially, 4 to 5 years after building in of crossings and switches, it usually comes to a significant increase of noise and vibrations. The reason for that is the fact it then comes to the wearing out or the so called "shallow groove". The existence of a shallow groove in tracks executed with grooved rails is the usual manner to ensure the passing of vehicle wheels over assemblies without impact. Namely, on a part of the traffic lane crossings, vehicle wheels are driving over wheel flange outlets (Fig. 2a). After wearing out of the shallow groove, traffic lane interruptions appear, causing impacts because of passing of vehicle wheels, because the wheels are no longer driving on the wheel flange outlet but on the wheel tread, Figure 2b.

![Fig.1 Survey of crossing paved by concrete plates.](image1)

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![Fig.2 Wheel movement over crossings: a) new crossing; b) worn crossing](image2)

Fig.2 Wheel movement over crossings: a) new crossing; b) worn crossing

Because of a large number of complaints by citizens regarding noise and vibrations appearing because of tram traffic on Jurisiceva-Draskovicvea intersection, the company of Zagreb Municipal Transit System (ZET) contracted the Faculty of Civil Engineering at the beginning of 2006 for the provision of a technical solution aimed at the reduction of adverse impacts on humans and on the surrounding buildings. The tram track structure at the crossing was performed by way of a discrete system of track leaning on the base (distance of fastening 1 m), while the track pavement was performed by AB plates. By the Terms of Reference it was asked for a decrease of noise and vibrations, provided that the existing bearing places are kept, as well as the existing manner of track closing. For the purpose of vibration reduction, continued track leaning, by way of the use of the material Icosit KC 330U, a system that was previously completely tested on the testing range [2] was proposed. A continuously leaning track ensures a better transmission of forces to the base, and diminished spreading of noise and vibrations caused by trams moving [3].

Based on the results of the conducted preliminary research and because of the fact that it is necessary to intervene within the track structure, but keeping thereby the existing track fastenings, and the existing system of track closing (by AB mounting/dismounting plates), the proposed solution for noise and vibration decrease was based on the idea that, in the part between the existing bearing places, the rail foot should be coated by an elastic material, however up to a height, which would not interfere with the building in of inserts along the rail collar and the building in of AB plates. A survey of the existing and the proposed track structure is shown in Figure 3 (Fig. 3a – Standard tram structure, TYPE A; Fig. 3b – Modified tram structure, TYPE B).
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2 Measuring of noise and vibrations

In order to establish the actual effect of the applied technical solution, noise and vibration measurements were conducted, before and after the work on track reconstruction, and that on the same measurement spots. The measurements of noise and vibrations in the field were compared with the results obtained on the testing range [2].

2.1 Description of measuring location

Jurisiceva-Draskovicova intersection is placed in the very centre of Zagreb and it is very important for the functioning of the tram transport, Figure 4. The intersection ensures the connection of the western and the eastern, as well as the northern and the southern parts of the city. Seven tram lines are frequenting the crossing, Figure 1. Daily, 1004 trams pass the crossing in one direction, and tram tracks are only 5 to 8 m away from business and residential buildings. The ground plan of Jurisiceva-Draskovicova crossing and the position of the measurement points, on which the measurements were conducted, is visible in Figure 5. Vibration measurements of the base were conducted on measurement points MP-1 (directions: North-South and West-East) and MP-2 (directions: West-East and South-North). The survey of noise and vibration measurement is shown in Fig. 6 and Fig. 7. Since by the "Regulations on Maintenance of Railway Lines and Railway Facilities" a maximum speed of circulation over crossings and switches of 10 km/h is proscribed, the velocities of the vehicles during the measurement were ranging from 7 to 10 km/h. After vibration measurement before reconstruction, works on exchange of tracks, crossings and switches began. When reconstruction works were finished, vibration measurement on the same measurement points, as before the reconstruction, had started.