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Relationship between weight of the heavy trucks and traffic noise pollution in the viewpoint of feasibility of fines for exceeded noise – a case study

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Abstract

Noise, as undesirable sound can be annoying and in extremes it may cause physical and psychological damage. Traffic is significant generator of noise, which cannot be avoided. Relation between traffic volume and traffic noise is well known, as well as the fact that heavy vehicles are generating more noise regardless of the speed. This paper discusses relationship between vehicle generated traffic noise and vehicle weight with focus on overloaded vehicles to establish relationship between the two and to determine feasibility of fines for exceeded noise. As systems for measuring traffic noise and portable weigh in motion systems are becoming increasingly available, they can be used to collect freight noise and weight data.

Keywords: Noise pollution; heavy traffic; weigh in motion; fines; exceeded noise.

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1. Introduction

Noise is an undesirable sound emanated from different sources. It can be annoying and in extremes it may cause physical and psychological damage. While exposure to noise emanating from many different sources can be avoided, traffic noise is perhaps the most difficult source to avoid. Traffic noise might reduce property values. As a result, planners, policymakers, and legislators must consider the noise damage caused by motor vehicles when evaluating transportation alternatives. Growing number of heavy trucks are causing significantly higher noise levels and since noise level increases with traffic volume in exponential manner with unknown relation between weight of the vehicles and their generated noise, situation is becoming worrying.

1.1. Traffic noise

Noise is level of sound which exceeds the acceptable level and as a result creates annoyance. As with sound, the basic unit is decibel (dB). The decibel is a logarithmic unit, which expresses the ratio of the sound pressure level being measured to a standard reference level, which is usually the threshold of human hearing. The majority of sounds detected by human hearing are within the range of 0–140 dB. The noise created by traffic normally resides in the range of 50–95 dB. Traffic noise and in particularly vehicle noise is created by engine and exhaust system of the vehicles, aerodynamic friction, interaction between the vehicle and road system, and by the interaction among vehicles. Generally, heavier traffic volumes, higher speeds, and greater numbers of trucks increase the loudness of traffic noise. Defective mufflers or other faulty equipment on vehicles can also increase the loudness of traffic noise. Any condition (such as a steep incline or overloading) that causes heavy laboring of vehicle engines will also increase traffic noise levels. In addition, there are other more complicated factors that affect the loudness of traffic noise, such as lateral distance from the road, terrain, vegetation, pavement surface texture, and man-made obstacles (Newman, 1985 and Subramani et.al., 2012).

In the European Union, about 40% of the population is exposed to road traffic noise with an equivalent sound pressure level exceeding 55 dB during daytime, and 20% are exposed to levels exceeding 65 dB. When all transportation noise is considered, more than half of all European Union citizens are estimated to live in zones that do not ensure acoustical comfort to residents. At night, more than 30% are exposed to equivalent sound pressure levels exceeding 55 dB, which are disturbing to sleep. Noise pollution is also severe in cities of developing countries. It is caused mainly by traffic, and on densely travelled roads the equivalent sound pressure levels for 24 hours can reach 75–80 dB (Yoshida, 1997).

1.2. Weigh in motion

Weigh-in-motion systems have been traditionally used to collect freight traffic data to support transportation planning and decision making activities. As high axle loads are responsible for road and bridge damage, the aim of any WIM system is to obtain accurate axle load and gross weight information. Despite the dynamic interaction between the vehicles and the pavement, which affects accuracy of WIM results, weighing in motion is recognized as the only method which can measure axle loads of the entire population of vehicles on a road section, including the overloaded ones which successfully avoid other modes of weighing. It is therefore the most efficient way to collect unbiased data on heavy freight vehicles. There are two major groups of WIM systems on the market, the ones that weigh with sensors built into the pavement and the bridge WIM systems.

B-WIM systems are applied on existing bridges or culverts which are transformed into undetectable weighing scales. For this purpose, the structures are instrumented with strain measuring gauges and axle detectors. Strains are collected on the main longitudinal members of the bridge to provide response records of the structure under the moving vehicle load. Until today, the traditional axle detectors on the pavement have been mostly replaced with FAD, the free-of-axle detector instrumentation, which uses additional sensors under the bridge to capture axle information (Žnidarič, 2018).

Bridge WIM is particularly appropriate for short-term (up to several weeks) measurements, as it can be easily installed and detached from the structure. Unlike the situation with pavement WIM systems, accuracy of the results of portable installations is not different than that of permanent installations.

Data collected with B-WIM measurements are used for a number of applications, including traffic studies, pavement and bridge design and assessments, detection of overloaded vehicles, etc. The commercial B-WIM system, called SiWIM®, was developed in Slovenia as an outcome of research performed in the COST Action 323 (2002) and 4th Framework Programme project WAVE (2001), both financially supported by the European Commission.

2. Case study

In order to analyse relationship between weight of the vehicle and generated traffic noise, a location with a bridge in vicinity was selected, where combined measurement of traffic noise, traffic volume and weigh in motion could be performed at the same time. Road section was straight, with no obstructions, no inclination and vehicles were traveling with constant speed.

2.1. Traffic volume and traffic noise

Integrated system TOPO.slp, produced by company RTB from Germany (Figure 1) was used for traffic count, classification and noise measurements. The lateral radar is used to measure the length and speed of vehicles and also contains an acoustical classification. Based on the reliable recognition of the axles and the determination of motor position the classification according to 8+1 classes and differentiations which go beyond, the differences between trucks and busses or motorcycles and compact cars are determined with almost no mistakes. Based on the geometric vehicle characteristics the detectors carry out this classification: Bicycle, Motorcycle, Compact car, Passenger vehicle, Delivery van (up to 3.5t), Car with trailer, Truck (over 3.5t), Truck with trailer, Tractor trailer and Bus. For each individual vehicle noise footprint is collected. Integration of the system in a standard guide post hides system in plain sight.

Fig. 1 TOPO.slp system

2.2. Bridge-WIM system

Portable B-WIM system SiWIM®, produced by company Cestel from Slovenia (Figure 2) was used on a short span bridge in vicinity of the noise measurement on the same road section. Strain-gauges installed under the bridge were used to detect and weigh each individual vehicle. Data collected consisted of axle and gross vehicle weight, axle distances, vehicle class, speed and direction. Collected data was compared with regulations and every vehicle, exceeding axle load or gross vehicle weight was also marked as overloaded.

Fig. 2 SiWIM system

Both systems were time synchronized for the purpose of data integration.

2.3. Analyzing data

Synchronized measurement lasted for a 21 days and data from 33.005 vehicles was collected and analysed. Majority of vehicles were cars, cars with trailers and vans, 27.452 vehicles or 83.18%. The rest were trucks, trucks with trailers or semi-trailers and busses, which accounted for 5.553 vehicles or 16.82% of all vehicles (Figure 3).

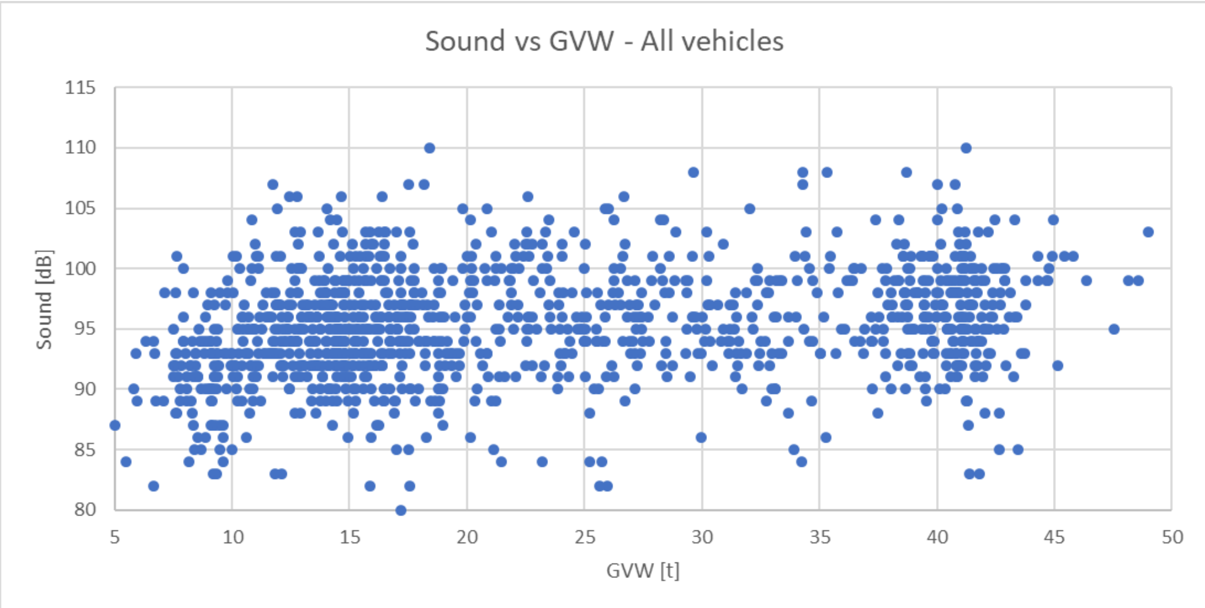

Fig. 3 Traffic noise for all vehicles

It is not that obvious, that heavy vehicles are generating more noise than light vehicles, regardless of their speed.

Heavy vehicles have noise figures between 80 dB and 110 dB and on average, heavy vehicles have generated noise well above 90 dB.

Introducing weight of the vehicle into available data, vehicles were analysed according to vehicle type and each type also according to legal loading and overloading. As shown on example in Figure 4, where all rigid trucks are presented, light (empty) trucks, up to 18 tons have lower noise footprint than all loaded trucks. With calculated trend line and averages for different weights it become obvious that overloaded vehicles tend to generate higher levels of noise. Average noise value for legally loaded rigid trucks was 93,3 dB and for overloaded 93,7 dB, which is very moderate difference, mostly due to the fact, that rigid trucks can be two-axle trucks with legal limit of 18 tons, but also 4-axle gravel trucks with 32 tons legal limit. Table 1 shows average noise figures for legally loaded and overloaded heavy vehicles, including busses.

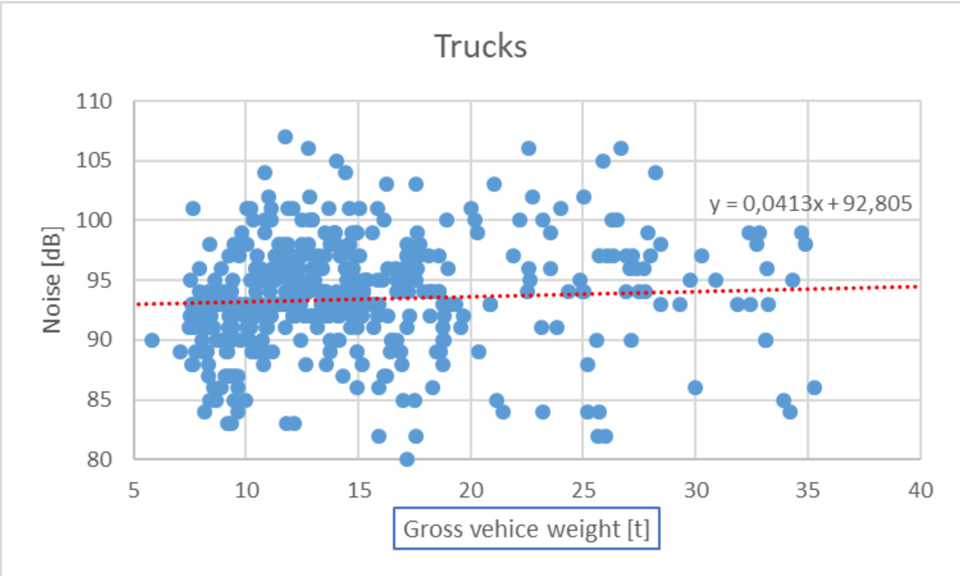

Fig. 4 Traffic noise of rigid trucks

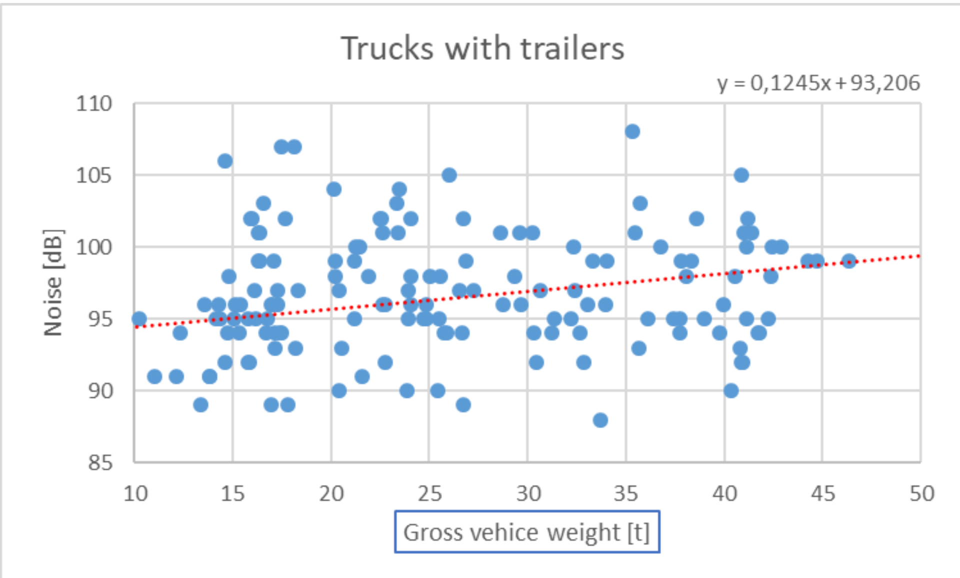

Fig. 5 Traffic noise of trucks with trailers

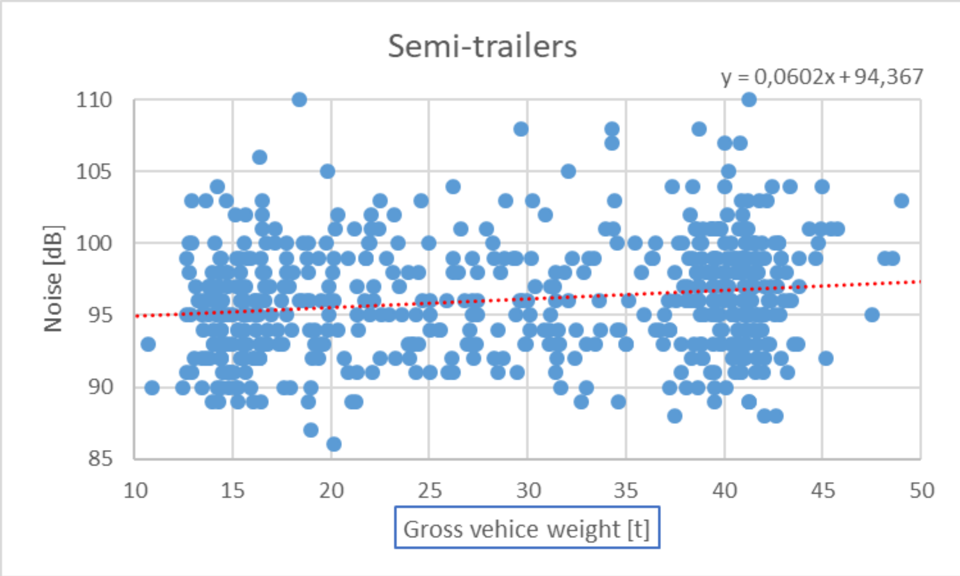

Fig. 6 Traffic noise of trucks with semi-trailers

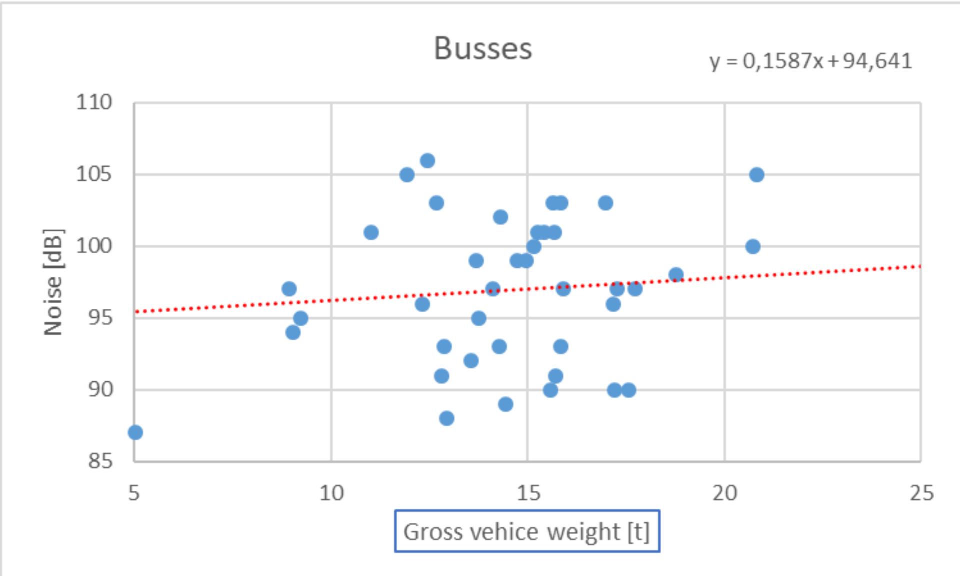

Fig. 7 Traffic noise of busses

Table 1. Average noise level for legally loaded and overloaded vehicles.

Type of vehicle	Legally loaded Average noise [dB]	Overloaded Average noise [dB]
Rigid truck	93,3	93,7
Trucks with trailers	96,0	97,4
Trucks with semi-trailers	95,8	96,9
Buses	96,6	100,4

If difference in noise levels for rigid trucks was not significant, this changes with trucks with trailers and also semi-trailers (figures 5 and 6), where average change in noise is around 1,5 dB. On average, overloaded busses were the loudest, but they represent minor part of heavy vehicles.

2.4. Fines

With available data it is possible to calculate fines according to the number of overloaded vehicles and types of overloading. Most national legislations specify exactly those fines. In the same way fines could be related to excessive noise where average noise per vehicle type would be considered as reference and progressive scale fines in relation to level of the noise could be calculated.

Fines for excessive noise generation could be introduced, but more in depth research should be performed, taking into account also the age of the vehicle and its EURO level emission standard.

3. Conclusions

Collected data on the vehicle generated traffic noise was compared with vehicle weight to establish relationship between the two and to determine feasibility of fines for exceeded noise. As systems for measuring traffic noise and portable weigh in motion systems are becoming increasingly available, they can be used to collect freight noise and weight data.

Traffic volume, traffic noise and vehicle weight can be related and presented case study shows that heavy vehicles tend to generate more noise if they are overloaded.

The strongest generator of noise are overloaded trucks with trailers and semi-trailers.

This case study shows, that fines could be directly related to overloaded vehicles, since they are generating on average 1,5 dB higher noise than legally loaded ones. Proper models to quantify the relationship between the noise and heavy vehicle weight should be developed in the next steps.

There were several limitations of the presented case study. Measurements were performed only on one location which represent specific traffic. Measurements should be performed on different types of roads in different geographical areas. Impact of the weather was also not studied. Heavy rain causes additional noise and also force drivers to behave differently, especially to lower their speeds and by such impact generated noise. Finally, analysis was limited during night time, as photos of the vehicles were not easily readable and confirming type of the vehicle was sometimes impossible.

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