Applied Acoustics 72 (2011) 479–486

Contents lists available at ScienceDirect

Applied Acoustics

journal homepage: www.elsevier.com/locate/apacoust

Technical Note

Noise mapping at different stages of a freeway redevelopment project – A case study in Brazil

Paulo Henrique Trombetta Zannin *, David Queiroz de Sant'Ana

Laboratory of Environmental and Industrial Acoustics and Acoustic Comfort – LAAICA, Federal University of Paraná, Centro Politécnico, Curitiba, PR, Brazil

ARTICLE INFO

Article history:
Available online 5 March 2011

Keywords:
Noise mapping
Noise pollution
Urban planning
Noise control

ABSTRACT

In economically developing countries such as Brazil, India and China, rising levels of noise pollution are associated with the accelerated growth of cities and the increasing circulation of automotive vehicles. This paper presents the results of an acoustic evaluation conducted in areas adjacent to federal highway BR-116, part of which lies within the urban limits of the city of Curitiba in southern Brazil. *In situ* measurements were taken of the noise levels, from which noise maps were drawn in different stages of the implementation of the road restructuring project called the Green Line. After calibration, a computational model was used to evaluate an operational scenario of the highway in the future. The results of the mappings were compared with reference noise emission values established by municipal legislation. The maps revealed the existence of noise pollution in the urban stretch of the federal highway in all the scenarios [$L_{Aeq} > 65$ dB(A)]. Efforts to control environmental noise in cities are aided by computational models for urban planning. These models are extremely helpful for environmental management and decision-making by public authorities for solutions to potential environmental risks, as is the case of urban noise.

1. Introduction

Noise is a well known source of pollution in urban and work environments. Sound pressure levels in urban environments have produced harmful effects on people's health. Several studies have investigated sound pollution in urban settings [1–10].

The World Health Organization [9,10] strives to warn, raise awareness of and promote actions against noise pollution. Environmental noise management is part of environmental impact studies and of guidelines for urban development in various countries.

In 2002, aiming to develop actions for noise management and control, the European Union presented its guidelines for environmental noise control and limits [11].

According to the EU Noise Policy Working Group 4 on Noise Mapping, the concept of noise mapping is: "Noise mapping covers the whole mapping process from the collection of raw data, the storage and retrieval of this data for computation/modeling, to presentation of information related to outdoor sound levels, sound exposure, noise effects or numbers of affected persons. This presentation can be in either graphical or numerical form" [12].

Since then the concept of noise mapping has been a prominent subject in several international scientific meetings and academic journals on acoustics and in journals that address issues of environmental pollution [13–20].

In emerging countries such as Brazil, India and China, the populations of large cities live with grave social en environmental noise pollution problems [2,21,22]. In Brazil, public instruments of noise control and management are still very precarious. The noise mapping concept has been used basically in academic work to study sound pollution in a few Brazilian cities such as Curitiba, Florianópolis and Rio de Janeiro. Pinto and Marques [23] point out that the environmental noise level assessment tool via noise mapping is rarely used in Brazil or in Latin America as a whole.

In Curitiba, the decision to implement a comprehensive public transportation system as part of its urban plan required the ongoing construction of new streets and high-speed roadways and modernization of the existing ones to meet the ever growing demand for public transport. The noise immission assessment of Curitiba's Green Line is part of a broader environmental monitoring plan that includes the evaluation of gas emissions and their implications for air quality, as well as archeological investigations in the areas where earth is moved.

In view of the above, this paper presents results of an acoustic evaluation carried out in areas adjacent to the federal highway BR-116, part of which passes through the urban limits of the city of Curitiba, where it turns into a major avenue with high population density along its marginal areas and is a corridor of public transportation.

* Corresponding author.
E-mail address: paulo.zannin@pesquisador.cnpq.br (P.H.T. Zannin).

0003-682X/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.apacoust.2010.09.014

This evaluation involved taking *in situ* measurements of the noise levels and drawing up noise maps. The acoustic surveys of noise immission levels were carried out during different stages of the implementation of the road restructuring project called Green Line, which can be divided into three stages: (1) The first one, which preceded the beginning of the civil engineering works, characterizes the operating situation of the old BR-116 highway. (2) The second one corresponds to the operation of the East Contour Beltway, which deviates part of the heavy vehicle traffic from the old BR-116 highway. (3) The third stage describes the operating noise levels of the new highway and freeway system, namely the Green Line. The future scenario was also evaluated. This future scenario was drawn up based on a projection of the noise levels generated by the future traffic demands resulting from the consolidation of the population densification predicted for the next 20 years. The mapping results were compared with the values proposed by Curitiba's legislation, which establishes noise level limits according to the time of day and to land use, in order to ascertain if the immissions are in line with legal regulations [24].

2. Description of the object of study – the metropolitan transport corridor – Green Line

Curitiba is situated in an economically strategic location. The city is situated midway between the main cities in the southeastern regions (to the north) and south (to the south) of the country. Due to its geographic location, the city is cut through from north to south by the federal highway BR-116. The urban stretch of the highway is 25 km long, with 28 residential districts spread along this length on both sides. Approximately 32% of the municipality's population (~600,000 inhabitants) lives in this area.

This stretch of the BR-116 highway has few overpasses, which hampers the traffic of vehicles and people between its east and west sides. The highway effectively divides Curitiba into two cities. In response to the need to facilitate public transit, several urban restructuring projects proposed alterations of the road network through the construction of several east–west highway overpasses and a beltway to handle part of the cargo traffic. This beltway, called the East Contour (East Line) (Fig. 1), deviates heavy traffic from the transport corridor along the urban stretch of the BR-116, called the Green Line.

The new highway and freeway system consists of two central concrete lanes for the exclusive use large buses and eight side lanes for vehicle traffic along the 25 km of the urban stretch of highway BR-116. The operation of the system is divided into two stages, according to the conclusion of the works. The first stage, which is already operating, corresponds to the 14 km of the south stretch. The second, corresponding to the 11 km of the north stretch, is slated to begin operating in 2012.

Figs. 2 and 3 show the alterations implemented for a section of the south stretch. A comparison of the two figures indicates that the six-lane structure has been transformed into a new 10-lane structure.

The expansion of the road network in the southern stretch led to a considerable increase in vehicle traffic. The volume of daytime traffic increased when compared to that recorded after the opening of the East Contour Beltway.

Table 1 describes daytime vehicle flows determined by visual counting.

In addition to the intensification of vehicle traffic resulting from the expansion of the road network, the transport corridor project foresees the progressive replacement of industrial installations by residential neighborhoods along the margins of the new avenue.

The project's future traffic volume projections suggest that the new corridor will have maximum capacity for a daily flow of up to 100,000 vehicles.

3. Measurements and computer simulations

Measurements were taken of the equivalent continuous sound level (L_{eq}) expressed in dB(A). The sound levels were measured at 28 points located at 500-m intervals, thus covering the entire 14 km stretch. The measurements were taken at three-month intervals from December 2006 through May 2009, always at the same points.

The measurements were taken according to the Brazilian NBR 10151 standard for evaluation in urban environments [25]. The Brazilian standard does not specify a minimum period of time for measurements, but recommends that the measuring time should

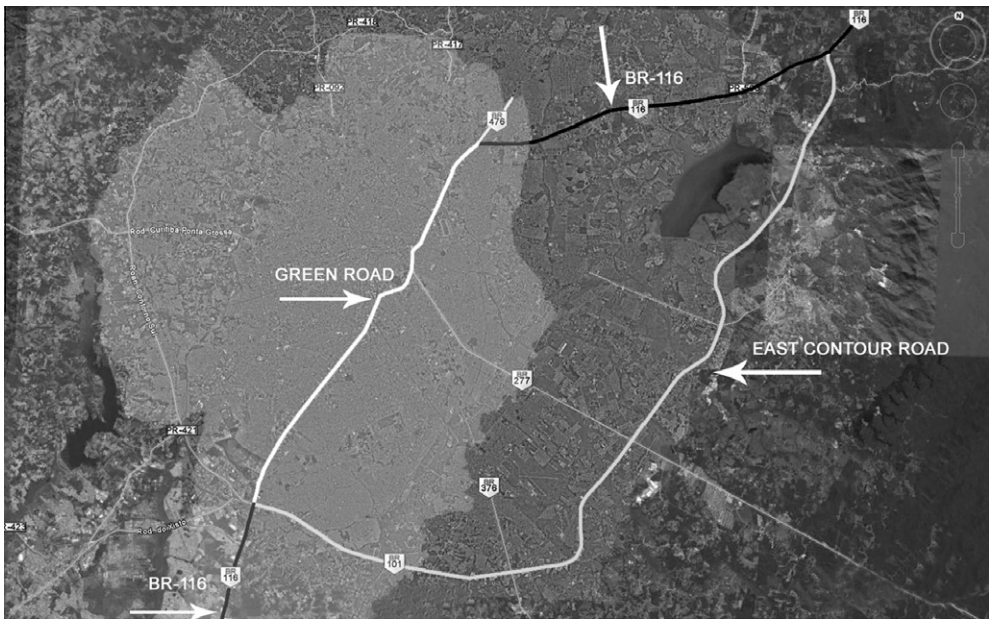

Fig. 1. Outlines of the BR-116 and the East Contour Beltway (East Line).