GUIDELINES FOR MINING AND QUARRY BLASTING URBAN AREAS BRAZILIAN REGULATION NBR 9653 UNDER CURRENT REVIEWED

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ABSTRACT

The Brazilian Regulation NBR 9653 is a guide intended to evaluate mine and quarry blasting effects in urban areas. The first version, written in 1986 by the Committee of the Brazilian Associate of Technical Norms, is currently being revised. Current regulations specify a maximum PPV limit of 15 mm/s (0.59 in/s) without consideration of frequency or type of structures being protected. The present regulation is still a draft and it is not validated. Several different agencies and institutions have participated in the Committee such as the Environmental Agency from the State of São Paulo (CETESB), University of São Paulo (POLI-USP), University of Rio Grande do Sul (UFRGS), National Department of Mineral Resources (DNPM), Aggregate Industry (ANEPAC and SINDIPEDRAS), besides a number of industry representatives, explosives manufactures and independent consultants. The present regulation proposes to modify the limits of particle velocity and introduces new definitions and criteria for evaluation of vibrations, as well recommendations to address blast vibration complaints.

OBJECTIVES

Current regulations address methodology to reduce possible blasting risks in urban areas, using compatible parameters with the actual technology to protect the population around the mine, and, specifically, structural damage and annoyance complaints. The regulations are applicable only to ground vibration, airblast, and flyrock from blasting activities and are optional for application in mines not located in urban areas. The regulation must be applied only in regions where houses exist. In blasting locations where there are no structure, these regulations to do apply

The current regulations allow vibration and air blast limits up to 15 mm/s (0.59 in/s) peak particle velocity (PPV) and 134 dB, respectively. Draft revisions to the regulations propose changes to PPV limits and introduce frequency as a parameter to be evaluated.

EVALUATION CRITERIA

The Committee of the Brazilian Associate of Technical Norms CE 18.205.02 determined the safe limits of vibration and air blast to be used in the current regulations based on the following:

- Evaluation of data from vibration and air blast measurements for typical blasting in different quarries and mines in Brazil
- consulted with different international norms and regulations to verify the limits selected
- consulted international literature involving seismograph monitoring and structural damage correlated with velocities and frequencies of ground motions

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- reviewed theoretical studies comparing international vibration measurements with measured values in Brazil for different types of geology and blasting methodologies
- established parameters to correlate with structural damage base on available research and studies conducted in other countries

The committee was not able to support studies on structure response for the range of construction types in Brazil. Currently, there are no mechanisms in Brazil to organize large-scale structure response studies. Therefore, relying on existing literature from other researchers was the only option is developing vibration criteria. Additionally, Brazil possesses a wide range of construction types. Many quarries and mines are surrounded by houses constructed without conforming to building codes. It is therefore very difficult to take into consideration the quality of urban construction surrounding quarries and mines ion Brazil.

COLLECT DATA OF VIBRATION AND AIR BLAST MEASUREMENTS

Vibration and air blast measurements were collected from different quarries and mines in Brazil, such MBR and Vale do Rio Doce Companies. The data was obtained from blasts in several types of rocks with different lithologies and geological structures, such as iron, diabase, granite, gneiss, carbonate, etc. There was no blast for which ground vibrations and airblast measured at any structure exceeded 50 mm/s (1.97 in/s) ground and 134 dB, respectively. It was determined that no damage was observed in the structures at or below these levels of vibration and airblast.

BASIS OF REGULATION DEVELOPMENT

The norms and regulations that were consulted came from the following countries:

United State – USBM Report of Investigation 8507 (1980)
Canada – NPC 201 (1983)
Germany – DIN 4150 (1990, revised in 2000)
England - BS 7385 - Part 2 (1992)
Italy - UNI 9916 (1991)
France - AFTES (1974) and Circular of the Environment Ministry (1993)
Portugal - NP-2074 (1994)
Swiss - SN 640312 a (1992)
Australia - AS2187 (1983)
India - Central Mining Research Institute (CMRI – 1991)

Norm BS 7385 (Part 2) from England was found to correlated best with Brazilian case studies and measurement data. The criteria used BS 7385 is very similar to that used in the Brazilian norm while building construction in England best duplicates construction in Brazil. Therefore the Committee adopted BS 7385.

The Committee also consulted numerous international papers regarding seismograph monitoring and vibration and air blast measurements correlated with structural damages. These papers served as a theoretical base to develop the Brazilian norm and to compare blasting measurements from different countries with those obtained in Brazil.

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STUDY GROUP

Since 1986, research data has became available on the effects of blasting on structures and human occupants. Much of these studies were used by members of the committee comprising mining engineers and consultants in drafting the proposed changes to the regulations.

Committee members re-analyzed this information and evaluated hundreds of new measurements at various sites over a large range of blasting conditions and for a large selection of structure types. Members considered vibration monitoring associated with the monitoring of the cracks in walls. Crack studies conducted at a mine operated by MBR, where ground vibration and wall crack were monitored over a 30-day time period, indicated that the crack movements were more related to the variation of temperature and humidity than to blast vibration. PPV values were found to have no influence in the evolution of wall cracks.

Other blast vibration monitoring projects were conducted by various consultants with similar results. The Committee members concluded that there was no evidence that blasting has ever resulted in ground vibrations that induced cracking in walls.

ESTABLISHING REPRESENTATIVE PARAMETERS TO CORRELATE WITH STRUCTURE DAMAGE

The parameters used in the regulation revisions include peak particle velocity (PPV) frequency, and airblast. PPV is defined as the maximum instantaneous peak value of a particle velocity at any point within an interval of time, among the peaks of the three components in the same interval of time. Peak particle velocity is measured in mm/s. Below 4 Hz, displacement has been suggested as a limit. Airblast is defined in the NBR 7731/83 as non-continuous acoustic energy with impulses less than 1 sec and are measured in decibels (dB). The parameter frequency is defined as: number of oscillations per second that the ground vibrates as the seismic energy created by a blast passes by a particular location. Frequency is usually expressed in Hertz.

PROPOSED GROUND VIBRATION AND AIR BLAST LIMITS

The vibration limits adopted from the BS 7385 are shown in Table 1 and Figure 1. The curve presented in Figure 1 is considered to be conservative threshold criteria to the vibration values. The limit to airblast is 134 dB or 100 Pa and will not be changed in the new regulations.

ADDITIONAL CONSIDERATIONS

The new blasting regulations are designed to accommodate changes of limitations on vibration and airblast, based on new research information. The regulation also set a minimum setback from residential building structures for blasting. The regulations specify blasting seismograph instrument specifications, procedures for measurements and the format for a standardized blasting log used for investigation and enforcement

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TABLE 1 Peak particle velocity limits proposed in the Brazilian regulation (NBR 9653)

Frequency (Hz)	Peak particle velocity (mm/s)	(in/s)
	15 - 20	0.59 – 0.79
15 - 40	> 20 - 50	> 0.79 – 1.97
> 40	> 50	> 1.97

Note: for PPV frequencies less than 4 Hz, a displacement criteria of 0.6 mm (zero peak) is used as limit.

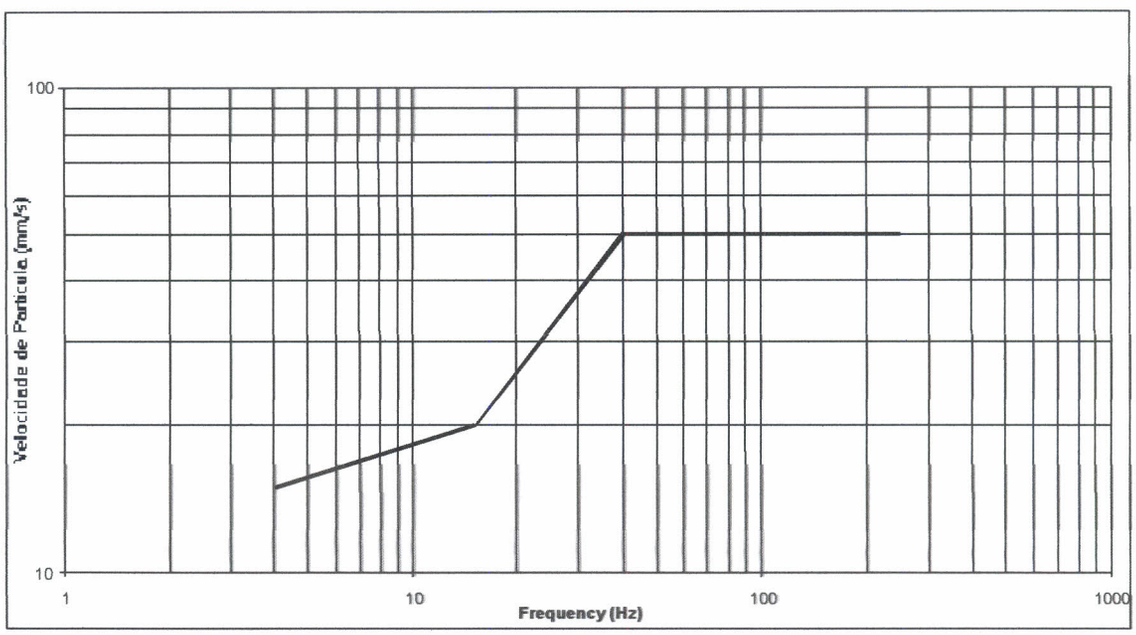

Figure1 Limits of PPV and frequency suggested by the NBR 9653 to mining and quarry in urban areas.

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