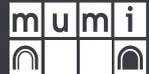


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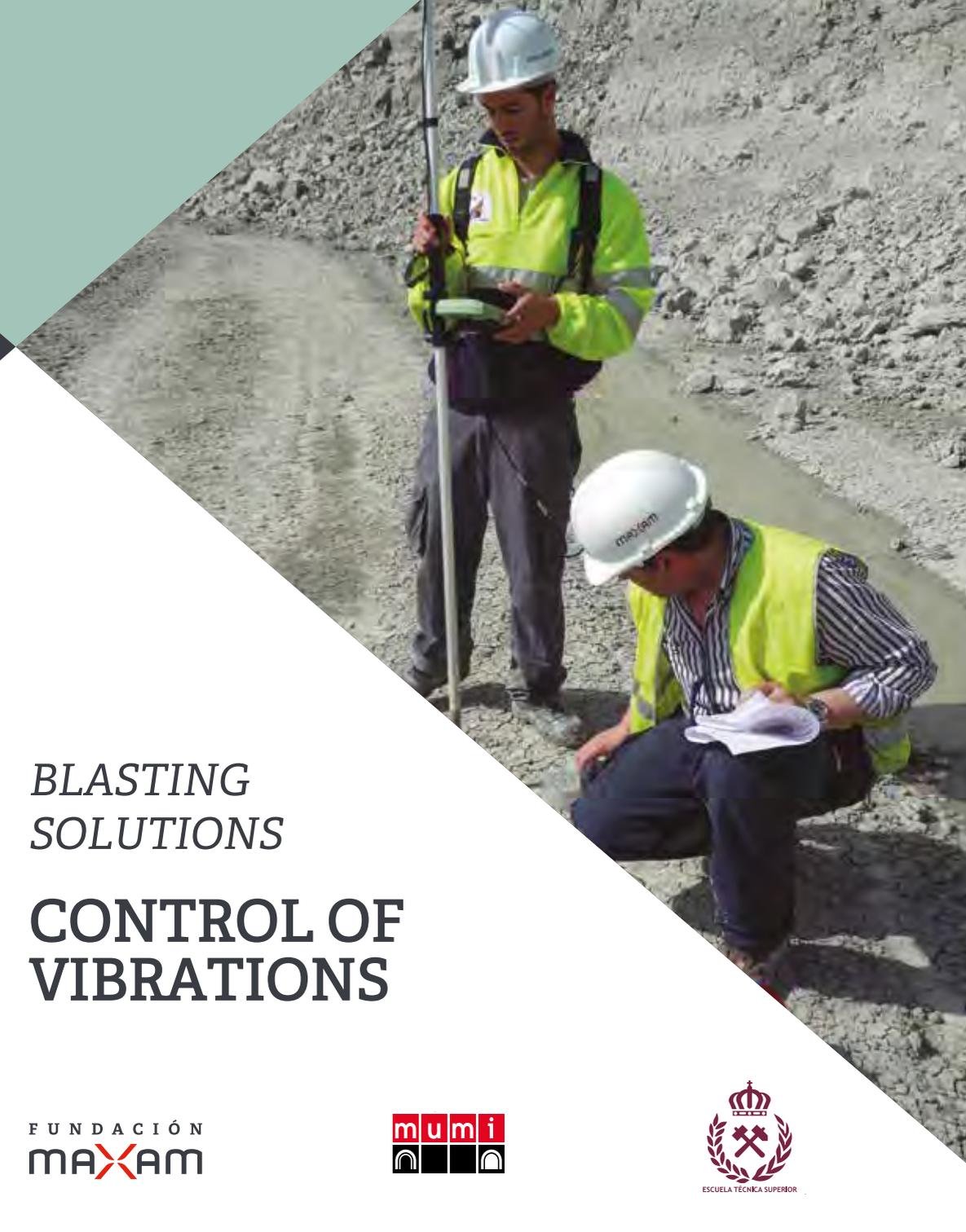
*BLASTING
SOLUTIONS*

**CONTROL OF
VIBRATIONS**

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The energy released by the detonation of an explosive charge is converted into heat and work by a rapid thermochemical reaction.

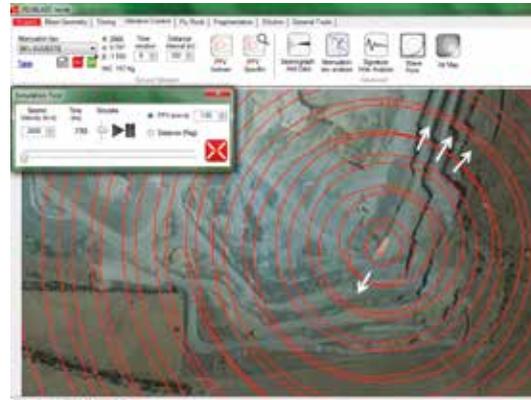
The way this energy affects its surroundings through energetic events marks the results of the blast. One such manifestation (among others such as fragmentation, displacement, noise and heat) is shock waves, which rapidly attenuate to take the form of seismic or elastic waves that move radially from the point of detonation.

In certain circumstances, vibrations may affect or damage nearby structures, and can be a permanent cause of conflict with people living in the vicinity.

Carrying out large engineering projects close to built-up areas and/or near sensitive structures is currently inconceivable without first characterizing the laws of attenuation for the land (relating evolution of particle velocity as a function of distance climbed), along with subsequent control of the vibration levels generated by the blasts through adequate sizing of the charges and determination of the initiation systems to be used.

SOME CHARACTERISTICS OF VIBRATIONS GENERATED BY BLASTING

The form or character of the vibrations generated by blasts may change as they propagate. As rock masses are not a perfect isotropic elastic medium, it is difficult to analytically predict the modifications the waves will be subject to. However, vibration studies can be used to statistically determine, to different degrees of reliability, the laws which govern attenuation of the land studied.

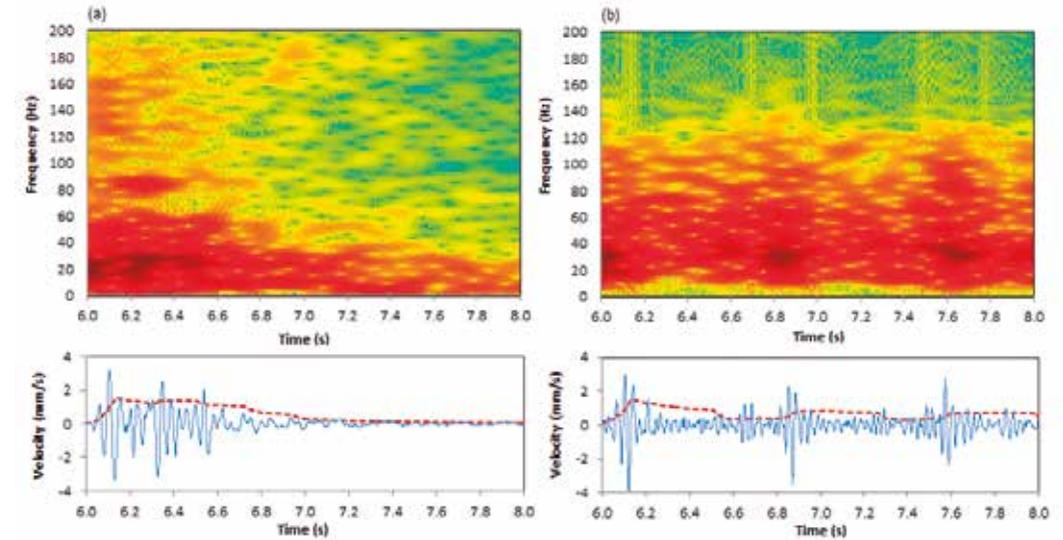


The arrows indicate the directions in which the detonation wave fronts are likely to overlap.

THE IMPORTANCE OF FREQUENCIES

The characteristics of the main frequencies found in blasting depend to a large degree on the geology (faults or geological accidents), means of propagation (types of rock, state of aggregation, etc.), and the delay times applied in the initiation sequence.

Seismograph.



Seismic signal frequency spectrogram.

The means of propagation heavily influences the frequency attenuation ratio. Waves that propagate with dominant high frequencies tend to filter more quickly in soils than in rocks, when analysed over short distances.

The main or dominant frequency of the vibrations generated by blasting can vary between 0.5 and 200 Hz. However, some of them tend to produce a more limited range of frequencies.

DAMAGE PREVENTION CRITERIA FOR STRUCTURES

In general, the permissible vibration levels are determined by standards, general recommendations, experience or, in some special cases, by specific dynamic calculations. In the case of Spain, the criteria of Standard UNE 22.381.93, "Control of vibrations produced by blasting" apply. This standard distinguishes three types of structures according to their quality of construction and state of conservation

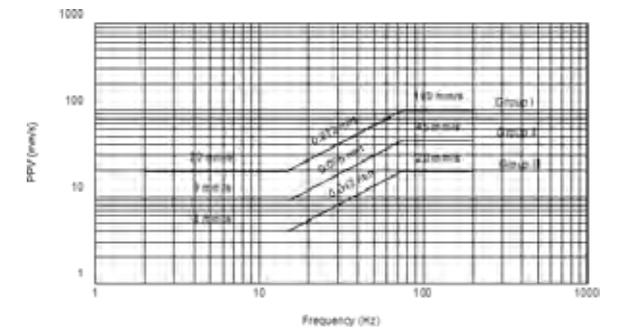


Chart of vibration limits of Standard UNE 22.381.93.

(type I: buildings and industrial units; type II; residential buildings, offices, shopping centres; and type III; structures of archaeological, architectural or historical value).

Controlling and predicting vibrations in all blast work is key to a successful project. Different prediction and control techniques can be applied depending on their degree of complexity, such as the determination of attenuation laws or studies that also involve analysis of elementary waves.

Be sure to contact MAXAM if you would like to add value to your mining project through control and prediction services for vibrations generated in blasts.