Comparison of shock waves provoked by various artificial avalanche release techniques, and of their effects on the snowpack

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ABSTRACT: the development of new systems should open new methods and improve efficiency of avalanche artificial releases. Current explosions are calibrated more regarding the possible and available explosible materials (solid or gas) than the snow itself. For many years and still now, one of the main parameter is the global supposed power of the explosion as expressed by the famous TNT equivalence. But, due to the diversity of snow at different scales (flakes, layer stack...), it is obvious that there is not a unique answer and that power is not the only way. In order to complete knowledge in this field, an experimental campaign has been performed to measure direct incident shock wave from different explosion sources and devices used for avalanches release. To assess the effect of this wave on the snow according to its quality, a protocol has been also initiated to evaluate the absorption of the snow and its ability to transmit the wave either to concentrate the effect through a pinpoint intensity or to spread it on a larger area with a distributed intensity.

KEYWORDS: artificial release, gas explosion, aerial overpressure.

1 INTRODUCTION

Preventive release is one of the main strategy used by ski resorts and transport networks against avalanches in winter. It uses artificial explosion of solid explosives or gas mixture with different advantages and characteristics for each category: with adapted practice, solid explosives can be used directly by pedestrian/skiers operators everywhere/when they can access. But, depending on national regulations, storage and transport can be quite complex and these products remain quite hazardous with unadapted behaviours.

On the contrary, gas is easy to store and transport but needs specific devices in particular to generate and contain the explosible mixture before ignition: this confinment can be provided by balloons or permanent volumes as the metallic pipe of Gazex or the cone of DaisyBell.

Finally, explosions to release avalanches are obtained from different ways : consequently, they have different characteristics as overpressure wave sources and for their influence on the snow mantel. This depends also on the relative position of the explosion source and the snow. In particular, explosives can be used either at the snow surface, at the ground level or in the air with different effects. For most gas devices, explosions occur first in the air with specific orientation towards the snow mantel.

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2 EXPERIMENTAL PROTOCOL

Among all combinations, only in the air explosions are compared between solid explosives, propan-oxygen and hydrogen-oxygen mixtures. These two last types are obtained using respectively the Gazex and new DaisyBell devices from the TAS Company (www.groupemnd.com)..

Considering that indirect measurements would include two many parameters (in particular due to snow diversity), the experimental protocol focuses first on direct evaluation of the incident aerial shock wave produced by these different sources.

The main element of the measurement is the free field blast pressure sensor 137A22 from PCB Piezotronics: this pressure probe is specifically designed for military applications and is mounted in an axial direction to the blast source with the sensing surface in a vertical plane (Walter 2004).

Data acquisition is done using an autonomous National Instruments CompaqDaq system with rate until 50 kHz.

3 SHOCK WAVES PRODUCED BY USUAL AVALANCHE RELEASE EXPLOSIONS

If the aerial 3D-evolution of a shock wave in a free field is well known and the TNT equivalence is the norm bur relative notion (Formby and Wharton 1996) for a long time, what is particularly interesting for avalanches is to quantify and compare current explosions used for artificial release as over/depression temporal wave.

Measurements made with solid explosives or gas (propan/oxygen and Hydrogen/oxygen mixture) show quite large differences: if the shape of the pressure curve is globally the same with a hard several hundred milli-bars peak followed by a first depression phases, results show different durations of the global wave: in particular for an equivalent intensity, the propan/oxygen wave is two times longer than the hydrogen/oxygen one. This is clearly linked to the wave speed in the air: the propan/oxygen one is also the lower one.

It is finally to note that, just under the Gazex or the DaisyBell devices, the sensor shows a very deep depression zone just after the shock wave itself. This phenomenon has to be confirmed and better quantified by other means but could be very interesting for the purpose of avalanche release.

4 SHOCK WAVE / SNOW MANTEL INTERACTION

In the interaction between a shock wave and the snow mantel, different scales have to be considered: from the flake and snow layers scale to the site and slope scale. Different effects should also occur: the direct shock wave penetration in the snow mantel with possible internal cracks and the global evolution of the surface pressure (over and depression) (Binger et al 2006).

With the spherical growing of the shock wave in the air from the explosion source, one compromise must be found between the shock wave intensity and the impacted surface: a distributed average shock on a larger surface or a punctual maximum shock ? This compromise must be adapted by the right distance and the power of the explosion. It should depend on the type of snow: dry and fresh snow or wet ''spring'' snow.

In particular with the development of the DaisyBell system (Berthet-Rambaud & al 2008), the operator can choose at least the best height by the right position of the helicopter. In order to improve knowledge and complete operations guide for such systems, a database is being built from in situ experiences and specific tests. To initiate new results, preliminary tests were performed at the end of last winter: due to organisation and safety reasons, only spring snow could be tested.

The main idea is to measure the ''dissipation'' and the transformation of the incident shock wave through a snow specimen. With only one sensor, this one is first located at the specimen entrance to obtain the reference input. Then, the snow specimen is added and characterised mainly by its density and its thickness.

First results show a great dissipation already from some tens centimetres of spring snow. This confirms that the direct penetration of the shock wave can be very limited.

These tests provide also very interesting information to improve the experimental protocol for further winters. The question of the specimen is the crucial point and clearly, adding an external specimen cannot be a satisfactory solution because of the transformation of the snow, modification of the layers... Secondly, as the shock wave is tridimensional and can pass over obstacles, the sensor has to be itself in the snow not to measure indirect waves.

So new developments are foreseen to settle sensors at different heights before winter and to let the snow mantel grow naturally around the sensors before to make explosion.

5 CONCLUSIONS

These tests are a very preliminary study of the shock wave characteristics of current explosion sources used for avalanches artificial release. The main goal is to complete knowledge in this field to better use new device like DaisyBell or others. Of course, collaborations and exchanges are welcome !

10 REFERENCES

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