RECENT IMPROVEMENTS IN CATEX (AVALANCHE CONTROL ROPEWAY) TECHNOLOGY

Gilles BORREL[I]

ABSTRACT

The purpose of this paper is double. First, we present the device to people who don't know it. Then, we show the answers that have been brought to improve the method and remove its most serious drawbacks : a general survey of the problems encountered by the operators when using the CATEX, strengthening of the electronics and igniters against hertzian waves and lightning, new methods to set up the device and protect the towers, an increased use of radio-controlled carriers/descenders (C/D), the use of a simplified computer to help running the motor, the writing of a set of rules to increase the safety measures.

THE CATEX SYSTEM

A Brief Description

It is comparable to a skilift. Instead of carrying skiers thanks to towbars, the moving rope conveys an explosive charge up to the starting zone of the avalanche, by means of a grip. The towers are installed outside the important slide areas. The charge, 5 to 10 pounds, explodes over the snow cover, and not on its surface, this without any danger for the installation. Different methods are used to obtain the burst after the charge has reached the chosen fire point. It is possible to convey simultaneously several charges, as well as to descend them at the favorable blasting level over snow surface or to retrieve possible misfires. The controls and the motor can be sheltered into a little log cabin.

The Major Advantages

First, it is possible to blast without visibility at any time (in storm weather, at night). This can't be done using hand-thrown charges. Second, the system offers an excellent safety to the operators who don't have to venture in the starting areas, provided its drive cabin has been built in a secure area. Third, it is possible to release slides in several areas at a distance, as often as necessary, with a reduced staff (only 2 persons are needed), sending several charges simultaneously, by means of the cable. Then, the burst of a charge over the snow cover is more efficient than one being produced inside the layer or even at the surface (rifle, hand-thrown charge, ...). And lastly, the obligatory retrieval of a misfired charge is very easy if the installation contains a system which allows the retraction of this charge before its return to the drive station. From this, it would seem that no other system offers such a set of advantages.

I. Research engineer, Snow/Avalanche Department, CEMAGREF, Grenoble, France.

The Drawbacks of the System

Some drawbacks had to be removed to make the CATEX as interesting as the other remote control methods (gun). We can think of the following ones :

Avalanche conditions, very restricting for the setting up of towers in zones scoured by slides during the whole winter. As the rope must overfly the natural release points so that the CATEX should be efficient, it is sometimes impossible to avoid such hazardous slopes. Embarrassing choices have to be done.

The risk of a very long immobilization in the event of a cable deropement. Indeed the CATEX is designed to reach points that are man inaccessible in winter. This outstanding advantage can turn into a worrying drawback which may lead to freeze any activity in the risky area for the rest of the winter months, as it will be impossible to reset the rope onto the sheaves and keep the zone safe again.

The visual impact of the CATEX, which does not make it always fit very well in the landscape. The worst effect is when towers are set up on the crests. Sometimes, trees must be cut along the installation to make sure it is working properly.

The precautions to be taken in case of rime which slows down the work. The rime settles around the cable by wet, windy weather. Its density exceeds 0.5 and can reach almost 0.9. Its thickness can grow to such an extent that it may "stick" the counterweight to the top of its support tower, and then break the rope. Some areas (ridges, high plateaus) are subject to rime, more than any others. In that case, special measures have to be taken, such as a start of the cable in slow motion when beginning the blasting work.

The important strains the installation has to withstand, due to the wind. The French rules state that the CATEX must be able to withstand winds up to 160 km/h. when stopped and up to 100 km/h. when the charges are hanging from the rope. It occasionally happens in mountain environment that the wind speed exceeds these limits, preventing any blasting operation.

The positioning of the charge, which takes some time. It can take up to 12 minutes to put a charge in its most remote place on a 3-km. CATEX. This interval must be multiplied by the number of charges to get the total operation time.

The possible damages caused by the lightning and powerful hertzian waves. This is the most crucial hitch encountered in CATEX use. A lot of unexplained complications have already arisen such as the sudden self-lighting of the safety fuse without any command from the staff. The knowledge we get and the improvements we try to carry out in this field will be of the highest importance for the safety of the operators.

Lastly, the installation of an average CATEX can require a pretty high investment. Very often, American people who are using guns and cheap (for how long ?) ammunition during the whole winter do not understand how it could be interesting for them to give up a rather satisfactory technique for such an expensive unknown system. It's true that an average cost amounting to almost US.$ 50,000 per kilometer (or US.$ 80,000 a mile) makes you think. But one must not forget the major advantages of the CATEX as stated above when comparing the methods.

THE IMPROVEMENTS

General Survey on the Problems encountered by the Operators

As there are more than 150 CATEX installed in France, it has been necessary to carry out (1986-87) a survey which could allow to delimit the flaws of the system. It's in the field of the misfires that we counted the highest number of reported problems.

Setting up the Ropeway and Protecting the Towers

When we start on the design stage, we are now using a program which allows, combined with an accurate topographic survey, to establish the lengthwise section of each span, giving the following distances : chargeless rope to ground (snowfree), rime loaded rope (counterweight on its highest position) to ground, charge to ground. These data combined with correct estimates of the snow depth allow to bring right answers to the problem of rope catching up into the snow layer or charges dragging on the surface. But first it is absolutely necessary to carefully assess the avalanche threats on the towers by the means of an appropriate program, in order to calculate the possible strains against them and reinforce their base part. The use of guys must be avoided, as the snow creeping increases the stresses on the tower by pulling on these cables.

The best solution we adopted was to install "lambda" pylons where the expected superpressure exceeds 20 t/m^2 up to 6 m. Figure 1a. This kind of tower could withstand a pressure up to 50 t/m^2, which is higher than the one reached where we can reasonably build up a tower.

Another solution consists in welding two iron plates to make a wedge welded itself on a clamp collar to be fastened along a reinforced tower. This collar allows to fit in the device which will equally divide the snow flow. Figure 1b.

When setting up the CATEX, we pay attention to the trees for both avoiding to scar the landscape and to leave an obstruction close to the line , all the rope long.

The last problem we must fight against is the avalanche wind. One should note that a 100-m. span offers an average cable surface of 1 m^2 and that, on a 300-m. span with the maximum wind load on the installation (200 kg/m^2), the rope, which is pushed off the vertical plane, gets 20 m. longer between the 2 towers . The sudden effects of the avalanche wind can be greatly higher : if the movement of the counterweight is too short, the installation may be badly damaged (rope breaking, tower torsion). Thus, some CATEX counterweights may have a movement up to 55 m. due to block and tackle pulleys.

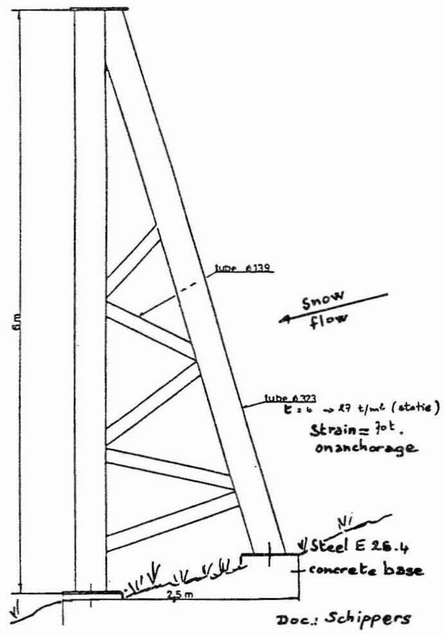

Figure 1a "Lambda" Tower

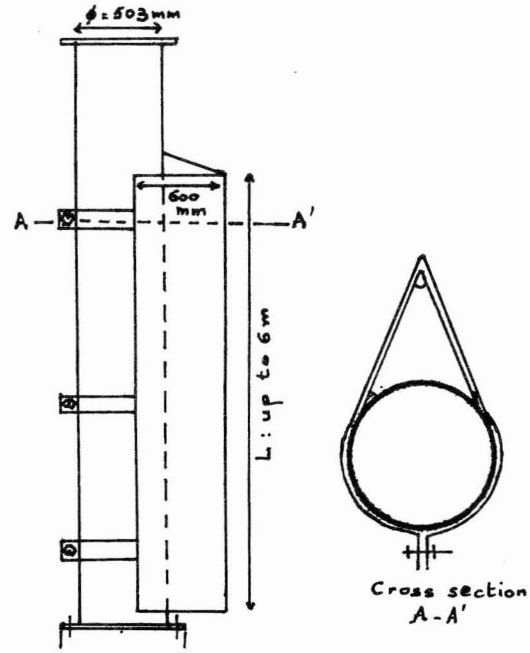

Figure 1b Clamped Wedge

<u>The Use of the Remote Control ; Arranging of the Sequences to be Programmed</u>

Although it creates new problems, the use of radio-controlled C/D's (carriers-descenders) becomes the norm. The increasing length of the CATEX's, up to 7.2 km (4.5 miles) for the French longest cable loop, leading to transport times above 15 min. makes it mandatory.

The principle is simple : first, the charge is carried to the burst point hanging below the box then, thanks to 3 radio coded messages it is lowered close to the snow surface and an electric igniter lights the **obligatory** safety fuse and lastly, after the explosion, the computer in the box detects a loss of weight and winds up the string. Afterwards, it proved to be more complicated : for example, losses of weight occurred after the wind-rocked charge had touched the snow on a deep slope, and the winch began to wind up the charge, its fuse burning. One can imagine the results !

So, the makers have brought some improvements in the way the computer controls the sequences of operations. After the third code is sent, the charge is descended onto the snow surface (on icy deep slopes, it may slide until the displayed lowering length is reached). The winch stops. Then, the computer tests a first loss of weight, for a period above 10 sec. (to cancel the wind effects). The winch winds up 60 cm. of string. New test : if the charge still rests on the snow for the same time, the winch winds up a new 60-cm. length of string. And so on, until the charge hangs again. Then, having tested that there's no more weight loss, it's then time to raise the charge 3 m. above the snow surface. After about 1 min. the explosive bursts, lightening the string. After this last loss of weight, the computer tests if there is any return of the information : "charge hanging", within a waiting period of 20 sec. This would show that in fact the loss was not the result of the burst but of another incident. If it happens the winch stands by for 30 min. as for a misfire. These new precautions allowed to save the operators a lot of trouble.

Speeding-up of the Control Operations

At any time, they must begin assessing that the whole rope is rime-free. The normal way to get it is to start moving the cable at the lower speed. If the rime layer is too thick, the risk of deropement is high. Therefore, it has been necessary to place a timer in the control system which automatically starts the motor and moves the rope for an adjustable time (3 to 10 min.) each hour. It allows to keep the device in good working order.

The problem of CATEX's moved by a gas or diesel engine has been solved by now. The maker installs a type of starter used in the hospitals to start the diesel emergency generators. It can put the bullwheel into gears too, thanks to automatic controls of the gearbox. After 3 attempts (with 10-second intervals) the program orders a 30-sec. break and tries thrice again. The starter stops when the alternator is producing power. The device allows to use lead batteries (96 Ah. for a 15-HP. engine) without any extreme cold problem.

We have seen before that, in the CATEX system, the operation duration and the investment cost are drawbacks which are mainly criticized. The only way to speed things up is to send several charges on the line at the same time to their eventual position and fire them in sequence. The use of the radio is necessary to remove the problem of a general failure with safety fuse already burning.

To get an idea of the time needed to carry out the work without preliminary de-icing, we can choose the case of an average CATEX as an example : a 3-kilometer moving cable distributed around a triangle composed of 9 equidistant towers, drive station included. If we take 3 minutes as the average time needed to prepare both any C/D box and its charge, we'll position 3 charges of explosive at respectively 2000, 1750 and 1500 meters, ready to be fired, within a period of 20 minutes. It will then be time to close the area and control the fire operations, and that can be done within a new period of 5 minutes.

Of course, one will rightly emphasize the fact that a gun shell is faster to reach its target, but this does not mean that the total time needed to carry such an operation right through the end is not longer, using a gun instead of a CATEX ; indeed, let's not forget that the only thing to do before one attaches the first charge onto the cable is to push a button to start the motor. The rest of the operations, except the clamping of the C/D's to the cable and the radio-controlled firing off, can be done thanks to a computer which reduces or increases the rope speed automatically when a grip reaches or leaves a sheave.

The Strengthening of the Electronics and Igniters

Considering the CATEX, the electric disturbances represent the top problem. First of them, the lightning causes considerable damages to the installation. The grounding of the towers must be done very carefully : the presence of a moist soil is essential, which is not the case at any place in mountain environment, particularly in summer. Nothing efficient can be done against lightning, but to avoid the drive stations installed on outside metallic platforms. The other kinds of electric currents (hertzian waves, static electricity) we ignored in our first approaches can reach voltages one cannot imagine, as we have not been able to measure them. We only know that they exceed the lab-obtained 25,000 V. anyway.

After a lot of spectacular failures had been noted, we brought some efficient improvements to several parts of the system. First, the C/D box is aluminum made now (strengthened bottom), instead of makrolon. This plastic, even though it is easy to cast and the strongest among all, favors the formation and the storage of static electricity. The strong winds and therefore, snow crystals on the move, hit the box and generate these charges.

Second, each circuit has been provided with its own Faraday cage. These cages are equipotential altogether and connected to the "-" on the batteries.

Third, some electronic devices, such as self coils, optically coupled isolators, blocking diodes have been inserted into the circuits wherever these parasitic and destructive currents could enter it. Then, we asked the makers to sell a high quality fuse and to improve its insulating properties since sudden combustions of the black powder, or even the conduction of high-voltage currents along the waterproof plastic made several caps burst before or immediately after having sent the first code. Then we asked them to make another type of igniter which could lower the number of electric problems and withstand the weather conditions on its way to the blasting point. See figure 3.

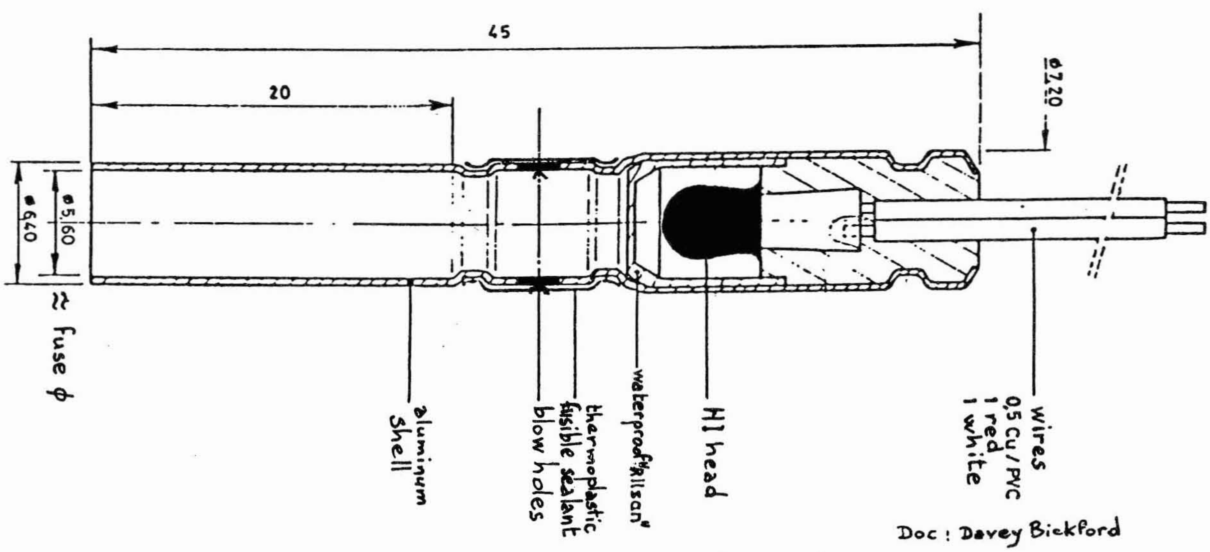

Figure 3 The New electric Igniter

And lastly, the power of the radio transmission has been lowered from 2.5 W. to 1 W. only. The radio-waves turned into induced current, the rope and the hanging wires of the igniter making a good antenna. Now, all the wires are screened and shortened (the position of the charge under the box has been modified) to avoid making a loop.

Statement of a Rule Set

This set of rules has been designed to make the authority checks easier on the plans of installations. Moreover, they are followed by the makers even if they aren't official standards. These rules clearly point out the main mistakes to avoid, taking into account the simplest systems which don't use C/D's, encouraging further improvements. The most significant is the one which gives the strains expected on the device, due to the wind , the rime load, the snow creeping and the avalanches. Most of them point out safety measures for the staff when operating the CATEX (it always must be rime-free when carrying up charges), handling the explosives and the transceivers, dealing with the misfires. Before the writing and spreading of these rules, most problems were due to their omission, in the hope of saving time and money in the construction, with the actual result of losing both on the operations.

CONCLUSION

One can notice that there are right answers to almost every drawback mentioned above. Our Department tries to improve the system, increasing the safety measures provided it does not freeze the development of the device. We have got a largely positive assessment of this artificial release method. That's why the CATEX becomes more and more widespread among the ski resorts and the road maintenance services in the Alps. It appears that this device would also deal very well with the avalanche control problem in the Rocky mountain range.