SNOW FENCES
PINO HACHADO INTERNATIONAL PASS

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ABSTRACT

The blowing snow is a major cause of traffic interruption through the International Pass Pino Hachado, accumulation generated by blowing snow is several times the product of the snow fall.

White wind storms have a strong negative impact on the security, affecting the visibility of the user.

Fences are porous structures that allow accumulate snow outside the road area. This paper describes the project and its most relevant aspects.

1. OVERVIEW

The Pass linking the east to Argentina in Neuquen province with Chilean Araucanía Region in the west, in the Andes of South America, 38º 39'south latitude, 70º 53' west longitude, and an altitude of 1884 meters above sea level. Fences are located in a section of National Route No 242, between Argentina Customs and Border with the Republic of Chile.

1.1. Trace of Route

National Route No 242, located on the Argentine side, has a sinuous trace inside a volcanic caldera, presents sectors with cross sections on hillside or over trough cut, with an average longitudinal gradient of 5%.

Figure 1 - Trace of Route No 242

1.2. Climate and weather

The climate is dry and cold, with extreme temperatures in summer reach 25 °C / 77 °F and winter -15 °C / 5 °F, the prevailing winds are from the southwest with speeds up to 120 km/h / 75 mph.

In 2005 was installed a weather station, giving meteorological parameters quantified the site, especially the speed and wind direction.

Figure 2 - Weather station

2. DESCRIPTION OF THE PROBLEM

Pass Pino Hachado, being located at low altitude (1,882 m), presents problems during the winter period due to the accumulation of snow over the road. The snowfalls has not high intensity, being the biggest problem due to accumulation by drifting snow, which produces traffic interruption for at least 25 days a year, with the consequent economic losses and utilization of maintenance resources due this situation.

During wind storms, the pavement grip conditions and visibility are changed dramatically, making difficult the maintenance works, which generally should be stopped for safety of personnel.

In the section between the Customs Complex and border limit, of 7 km in length, the snow accumulations due to drifting snow reach heights ranging from 3 m to 6 m, in short periods of time the route will be out of service, so the traffic should be stopped, restoring road conditions generates a high availability of personnel and equipments, and long periods of inactivity trough the Pass.

The presence of drifting snow is a phenomenon linked to the following factors: direction of the route respect to the prevailing wind direction, to the speed of winds, to the density of vegetation in the area and the form of surface relief transverse to the axis of the route.

Figure 3 – Maintenance after drifting snow

With respect to the orientation and intensity, we know that the prevailing winds are from the west - southwest and in this condition reach speeds of around 120 km / h / 75 mph, with gusts that exceed these values. While there are days when the wind reverses direction there is a moderate to low intensity and the transported snow is negligible.

Native vegetation that can be seen near the route is the Araucaria and some low-lying shrubs; it is noteworthy that the sectors affected by blowing have little or no vegetation.

3. DESIGN AND SNOW FENCES

Since the problem exposed, is a need to reduce the accumulation of snow on the road to minimize traffic disruptions, with this target we propose the possibility of using snow fences.

In Argentina there is no available literature on the subject snow fences, are considered the report of R. Tabler available online [1] as a reference, considering that the topography of the plains in the observed experiences, and therefore different from those present in the National Road Nº 242.

Then the following unknowns appear, is applicable Tabler method [1] for winding roads with cross sections on hillside or over trough cut?, Do local wind conditions and snow accumulation are consistent with those obtained from the weather station, will it be sensitive the condition of the road to the use of fences?

3.1. Collection of information

The determination of the critical sectors was held in conjunction with winter maintenance operators who took care of the road for several years, they pointed out five areas where they had problems with snow clearance tasks and causes delays in transit through long periods of time.

Comparing the characteristics of each sector, can intuit causes accumulation of snow, but not clearly shown where the direction of transportation and magnitude of it.

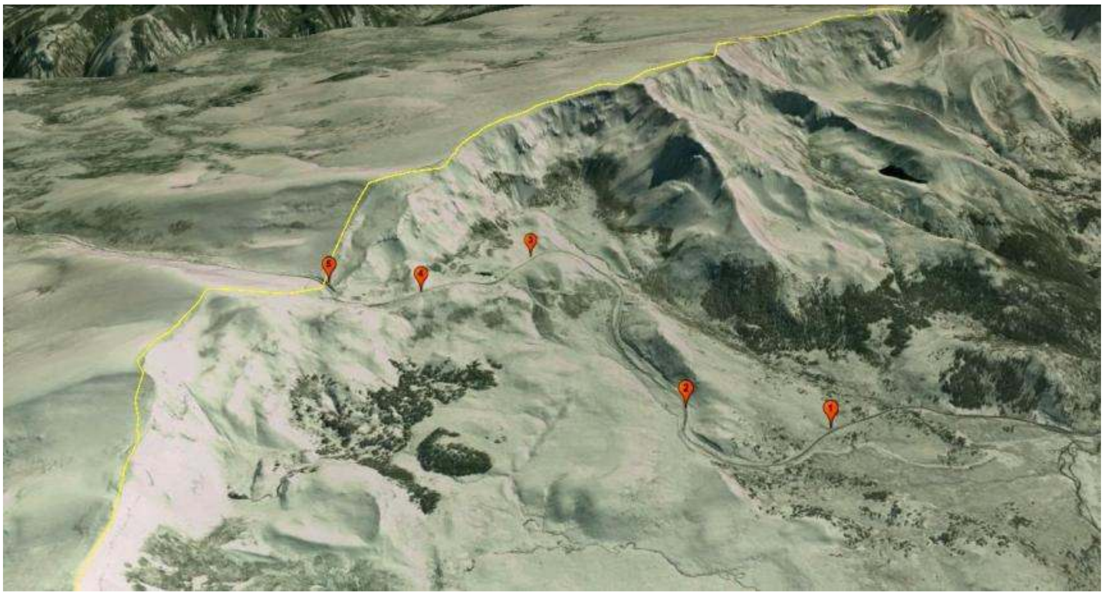

Figure 4 - Sectors affected by drifting snow

The geometric conditions of the surrounding terrain to the road were different; there are three different types in a total of 5 cases:

First, road section on hillside with negative slope:
This is the case of sector 1, the hillside has a negative slope of 15% with a terrace variable height between 3 m / 10 ft and 5 m / 17 ft.

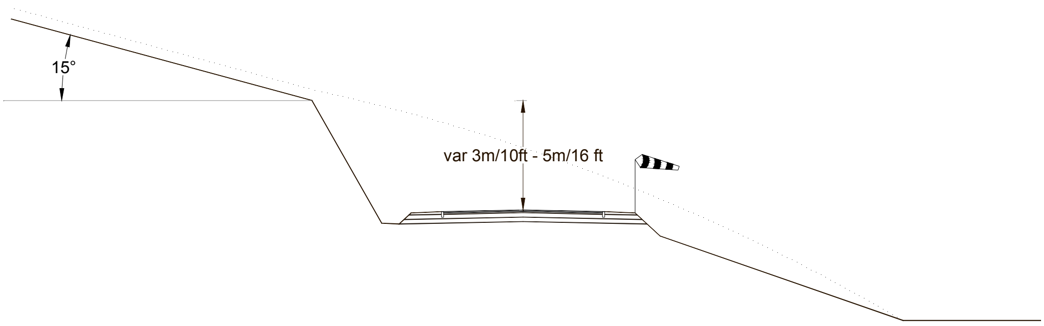

Figure 5 - cross section on hillside with negative slope

Second, cut on the hillside with sloping transport:
This situation occurs in sectors 2, 3 and 4, the carriage moving snow by a positive slope of about 10% to reach the route; this acts as a barrier that prevents movement of the snow, causing accumulation.

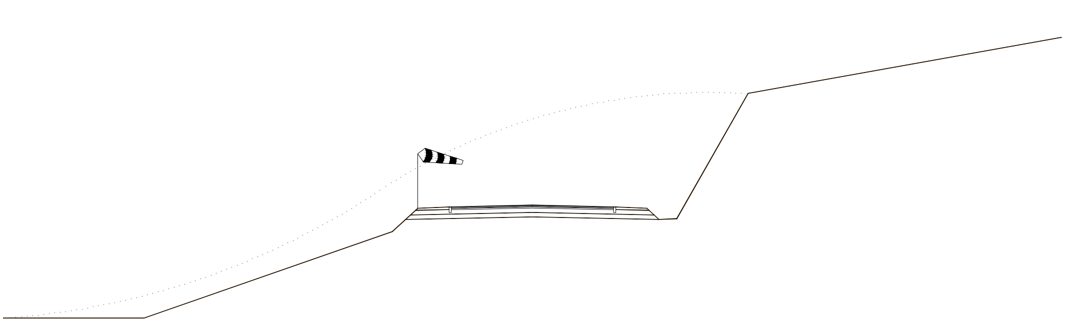

Figure 6 – cut on the hillside with sloping transport

Finally the cut drawer:
This situation is observed in Sector 5 and is the worst arrangement since the slope is important, therefore there is a large accumulation of snow and snow must be transported to areas of collection.

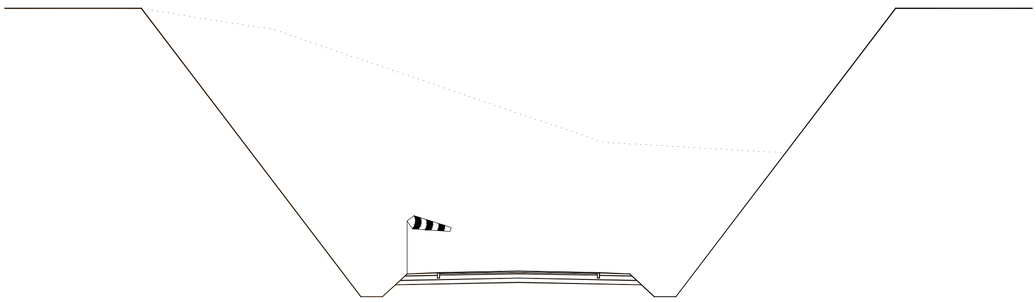

Figure 7 – Cross section trough cut

3.1.1 *Field Work – experimental Snow Fences*

It aims to determine the amounts of snow on move and where from they come, lets define the geometric characteristics of the fences. Hikes in the summer season and site characteristics related to the sectors affected the road the first hypotheses because the vegetation provides valuable information. The forested areas are the natural boundary for transport of snow, so the distance to these define the scope of drifting snow, on the other hand, the zero or low shrub vegetation is an indicator of the path in which the snow is mobilized, these bands show subtle depressions in relation to its surroundings due to the erosive effect of the wind, another element to consider is the inclination of the taller shrubs that give a clear idea of the prevailing wind direction in these areas.

This information could be completed in winter season through the use of experimental fences; they allow comparing empirical findings with the calculation methods set out in the reference literature.

Fences, obtained from recycled wooden pallets, have dimensions that allow transport them and place them manually, these individual panels of 1 m / 3 ft tall, are placed in rows of 10 m / 33 ft long at predetermined locations .

Due to the short length of the rows, the snow acquires a wedge-shaped configuration, this feature is useful, joining with a line the center of fence to apex of the wedge defines the perpendicular to the axis the searched alignment and provides information regarding the necessary space behind the fence for gathering snow.

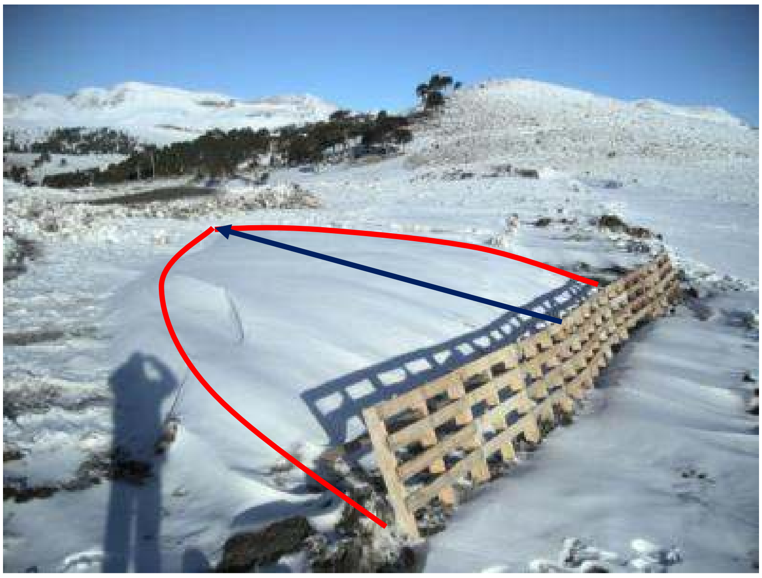

Figure 8 - Snow accumulated behind experimental fence

3.2. Construction and placement of fences

After defining the sectors of construction fences and their orientations, is performed structural design and verification of them, the model adopted is the type Wyoming.

For its realization was used ponderosa pine, provided through an agreement with the Forestry Corporation Neuquén.

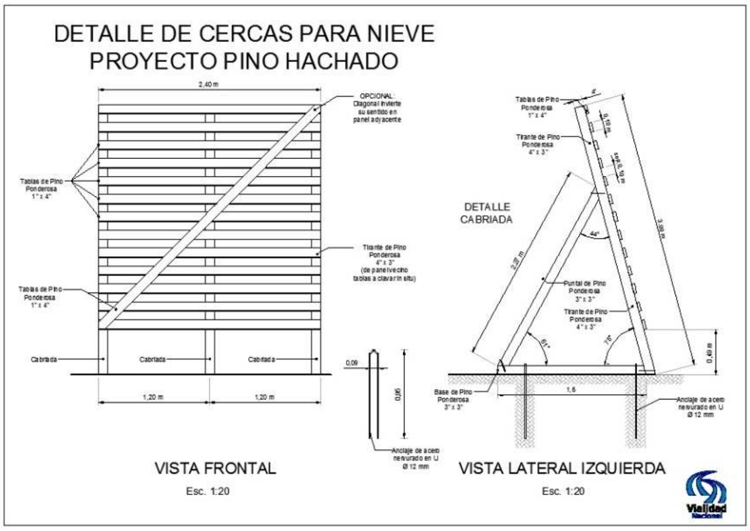

Figure 9 - Sketch of the fence

3.2.1 *Preparing the ground*

As this mountain area the surface have an irregular relief and low-lying shrubs exist, therefore it needed cleaning and leveling of the band in which fences shall be placed, in some cases running complementary structures for save natural accidents terrain, such as embankments and sewers.

3.2.2 *Construction and panels assembly*

The panels are built with tables whose width is 4 "to 6", The panels are built with tables whose width is 4 "to 6", with a porosity between 35% to 50%, the pieces are held together with spiral nails, forming panels of 3 m / 10 ft high and a width varying from 2.40 m / 8ft to 3.00 m / 10 ft, according the tables that the supplier has available.

Figure 10 - Construction of panels

The panels are carried by truck to the site at assembly, the final positioning is performed with a front loader. Displaying on the ground sills and joining is performed with them panel and struts in situ and finally anchors are placed to prevent the overturning of the fence.

The anchors are made with a reinforcement steel ribbed bar Ø 12 mm / N # 4 (1/2"), inverted U-shaped.

Figure 11 - Anchors

4. CONCLUSIONS

4.1. Operation:

Accumulation stages predicted by the theory of Tabler [1] are verified, in all cases the snow accumulation downwind is less than expected and varies according to the slope of the land where it is located.

Figure 12 - Stages of snow accumulation

For negative slopes on the order of 15 °, the downwind accumulation exceeds 30% the height H of the fence at its highest point and develops a length of 3H to windward and 12H downwind.

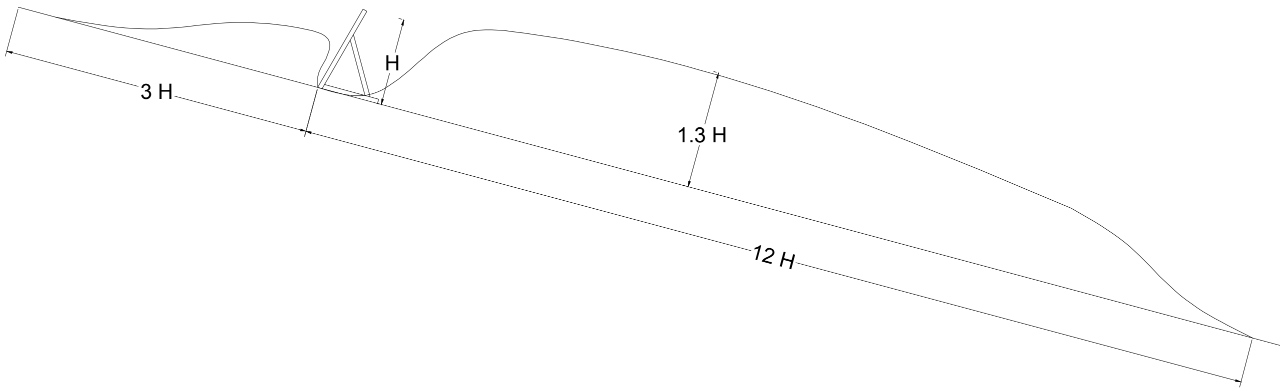

Figure 13 - Scheme of snow accumulation in negative slope

For positive slopes of the order of 10° the accumulation is less than the previous case, downwind reaches the height H of the fence at its highest point and develops long 5H 7H upwind and downwind.

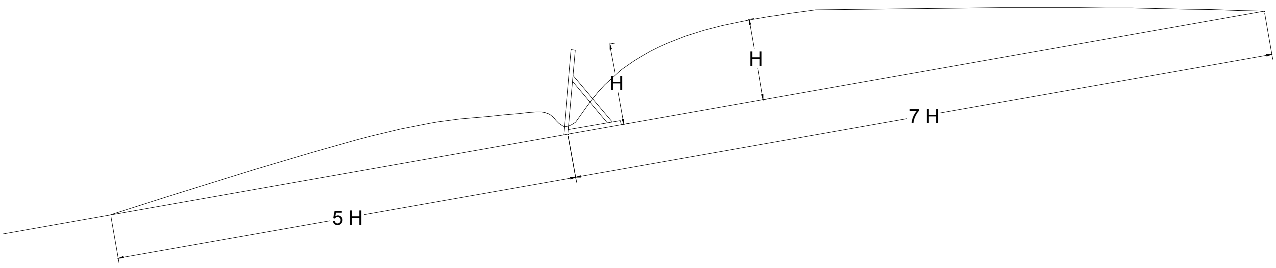

Figure 14 - Scheme of snow accumulation in positive slope

Sometimes snow overfills the hollow where the snow fence is located, the fence in such cases does not work and snow previously collected remains unchanged. For these cases are expected in the second stage of this project, the placement of a second line of fences, between existing fences and road.

The sectors where fences have been placed accuse significant changes in relation to the accumulation of snow on the road, the workers who keep road say that the sites where tasks previously performed with bulldozer and front loader can now keep with motor grader. Consequently causes a reduced rehabilitation times and less operating costs of equipment.

In moderate intensity wind storms as often happens, improvements in visibility conditions allow traffic for longer hours and provides more comfort for the users during those periods.

When the wind speed reaches the maximum, the visibility is very low and stops traffic for safety reasons, in these snowy conditions accumulation on fences is very important and on the road the deposition is reduced by approximately 80%.

Currently the closure of the passage is linked mainly to the formation of ice on the pavement.

Figure 15 - Images prior to fencing

Figure 16 - Images post fencing

4.2. Preparing the ground:

The terrain cleaning should not include soil removal, if the base of the fence is sunk below the natural ground level modifies the lower aperture of the fence, so it is no accumulation in the face to windward and the fence is covered quickly, losing its efficiency.

The sill must have good contact with the ground along its entire length as a bearing surface produced irregular, with time, the mismatch of the anchors due to the vibrations caused by the wind.

It is necessary to consider the implementation of a ditch near the bottom of the fence to evacuate rainwater accumulation occurs settlements and loss of adhesion of the anchors.

When performing the preparation of the seat base, consider that ground movements not obstruct drainage channels perpendicular to fences to prevent erosion and settlements.

4.3. Construction:

When the fences are located on sloping hillsides, with positive slope, efficiency is lower than expected in the calculations, so you should take a rematch at the height of approximately 30%.

Performing control of the wooden parts, not must have nodes which tend to detach from the section of the same, if the nodes are present must be rejected, or the piece must be reinforced to prevent the loss of ability or collapse.

It is convenient to place the beams on the edges of the panels, this allows laterally bind panel, and this causes redistribution of stress under the influence of wind gust.

4.4. Foundation:

Tabler guide [1] proposes an anchor system like the one in Figure 1, which consists of putting a bar of Ø 19 mm / No. 6 (3/4 ") into the ground and fix the fence with a metal clip U, by means of a bolt which connects the same with the beam and the sill. The proposed model leverage forces subjected to the clip and this tends to open, considering that the wood we use is much more compressible than Douglas fir used by Tabler, there is a risk that the nut and washer from sinking into the wood, allowing the U-clip is opened and hence the bar could slide.

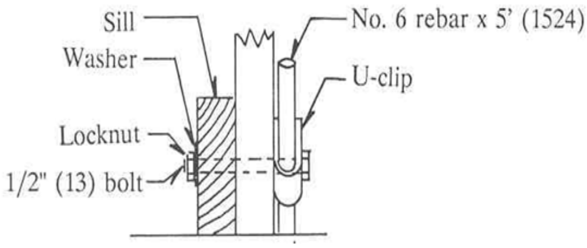

Figure 17 - proposed anchor by Tabler

Therefore adopts the model of Figure 2, which replaces bar Ø 19 mm / No. 6 (3/4 ") with a No. 4 (1/2") to be put into the ground as inverted U.

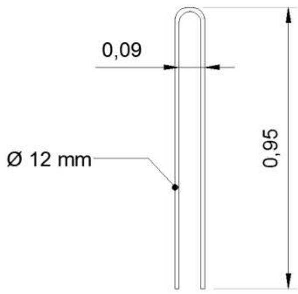

Figure 18 – anchor adopts

REFERENCES

1. Tabler, Ronal D. - Tabler & Associates, Snow Fence Guide. SHRP-W/FR-91-106, (1991) Strategic Highway Research Program National Research Council, Washington DC.
2. No other relevant literature available in Argentina.