FRANCE'S A75 MOTORWAY: PROTECTION FROM SNOWDRIFTS AT THE FAGEOLE SUMMIT

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ABSTRACT

The Fageole Summit, at an elevation of 1,107 m, is one of Europe's highest motorway passes. In addition to the constraints caused by its altitude, this area features various characteristics that promote the formation of snowdrifts, namely vast snow-covered zones (given the expanse of surrounding barren plateaus) and excavation profiles. The northern exposure and steep slope serve to exacerbate conditions whenever driving over the pass proves difficult. Two incidents involving snowdrift formation in 2005, both lasting 3 days (January 26-28 and February 15-17), resulted in the closure of this motorway (the A75) to all traffic.

In response, it was initially decided to install snow fences. The layout of such fences, whose impact is highly sensitive to wind direction, entailed an analysis of meteorological data provided by the weather monitoring station located right at the Fageole Summit, combined with results from a field survey conducted among personnel with the Regional Roads Directorate (DIR). This effort led to a draft proposal calling for the installation of fences along a length of over 2 km.

For 6 years, this design was closely monitored and improvements were introduced. However, since the efficiency of snow fences is so highly dependent on wind direction, it quickly became apparent that in light of past experience, the planting of wooded strips would offer a better solution in terms of winter serviceability at this site, where winds vary from northwesterly to northeasterly.

Back in 1990, a 260-m wide wooded strip had been set up along the then RN9 national highway (since upgraded to the A75). This strip, positioned today 25 m from the pavement, performs its function exactly as intended, though its lower branches have started to die and thinning out the growth has become necessary.

Encouraged by this experience, the present article will discuss the A75 case study, in providing an assessment of the specific practices adopted to control snowdrifts. Focus will also be placed on the current project to replace existing fences by woodlands as a more durable solution with greater capacity for integration into the landscape.

1. THE A75 MOTORWAY AND LOCAL CLIMATOLOGY: AN INCOMPATIBLE MATCH

1.1 The A75 Motorway

The A75 connects the cities of Clermont-Ferrand and Béziers (340 km distance) in 3 hrs 20 min. A key north-south transit corridor, attractive to motorists for its toll-free status, the spectacular beauty of the mountains it crosses and the exceptional engineering feat of the Millau Viaduct along its itinerary (the only toll crossing), this motorway is a very popular tourist route as well as an economic conduit and formidable rival to the A7 motorway to the east, allowing vehicles to bypass Lyon and avoid Lyon's renowned bottlenecks.

As a mountainous road with 45 km of sections at elevations above 1,000 m, the A75 itinerary includes the Fageole Summit (altitude: 1,107 m), one of two summits passed along the route, the other being Issartets (altitude: 1,121 m, making it Europe's highest motorway pass!).

Besides the constraints imposed by such high-altitude driving, the Fageole Summit features a number of characteristics conducive to forming snowdrifts [1]:

- relatively unprotected from the wind, the area consists of vast snow-covered zones (surrounded by extensive and practically barren plateaus),
- excavation profiles,
- a northern exposure coupled with a steep slope, two exacerbating factors that become especially acute under difficult driving conditions.

A weather monitoring station set up by the Massif Central DIR team located around the Fageole Summit serves to record wind speeds and directions along with the specific temperatures of this sector in France's Cantal Department.

1.2 Climatology of the Cantal Department [2]

The geography of the Cantal constitutes the first major natural obstacle to interfere with the westerly winds blowing from the Atlantic Ocean, producing a climatic variation from one side of the department to the other: the western part receives considerable rainfall due to the Atlantic influence and is wet and mild, while the eastern part is much dryer and cooler with heavy precipitation falling over the central relief. The effect of altitude also plays a role: the weather turns quite cold in winter. In the central highest section, altitudes easily top 1,000 meters. The cold is intense and snowfall frequent: on the Cantal peaks; the number of snowy days per year is around 50 at 1,000 m and exceeds 70 above 1,200 m, which is comparable to the situation in the Alps at similar altitudes. Despite this frequency, the amounts of snowfall tend to be quite small. The actual number of snowstorms making significant contributions to the snowpack height remains marginal: less than 150 cm between 1,000 and 1,200 m. As regards snowdrift formation, snow accumulation height is not the determinant factor; the focus instead is on the available quantity of snow and the presence of wind. The vast barren zones on the Saint Flour Plateau are exposed to both northerly and southerly winds: all ingredients are therefore in place to form snowdrifts.

Two episodes of snowdrift formation occurred during 2005, lasting 3 days each (January 26-28 and February 15-17), prompting authorities to close the A75 to all types of traffic. Photographs 1, 2 and 3 offer a glimpse of the conditions experienced during these periods.

Photograph 1: January 27th, 2005 / A75 at the Fageole Summit, traveling north-to-south (Source: DIR Massif Central)

Photograph 2: February 16th, 2007 / A75 at the Fageole Summit, traveling north-to-south (Source: DIR Massif Central)

Photograph 3: January 27th, 2005 / Montchauvet rest stop (Source: DIR Massif Central)

2. RESOURCES AVAILABLE TO PREVENT SNOWDRIFT FORMATION: OVER 100 YEARS OF EXPERIENCE TO DRAW UPON

The technology implemented to protect against snowdrifts is age old. The earliest article we uncovered was written in 1864 by Nordling and recounts a mission in Germany during which the topic of blowing snow received great attention as the railroads were being built. Field observations enabled establishing the first set of engineering rules (planting, transverse profiles and snowdrift screens) that would be reused, for example, by Morard in 1896 to protect the Lus-la-Croix-Haute railway line (see Fig. 1). In the United States, initial studies date back to 1905, sponsored by the Great Northern Railway Company, and continued to be refined through the mid-1930's. The extremely limited availability of vehicles suited to snow removal rendered this task so laborious that it stimulated ingenuous responses from facility managers at the time. Milling machines were introduced during the 1950's. Snow removal remained a Herculean task, yet it is a likely hypothesis that technical developments did diminish the reliance on snowdrift protection.

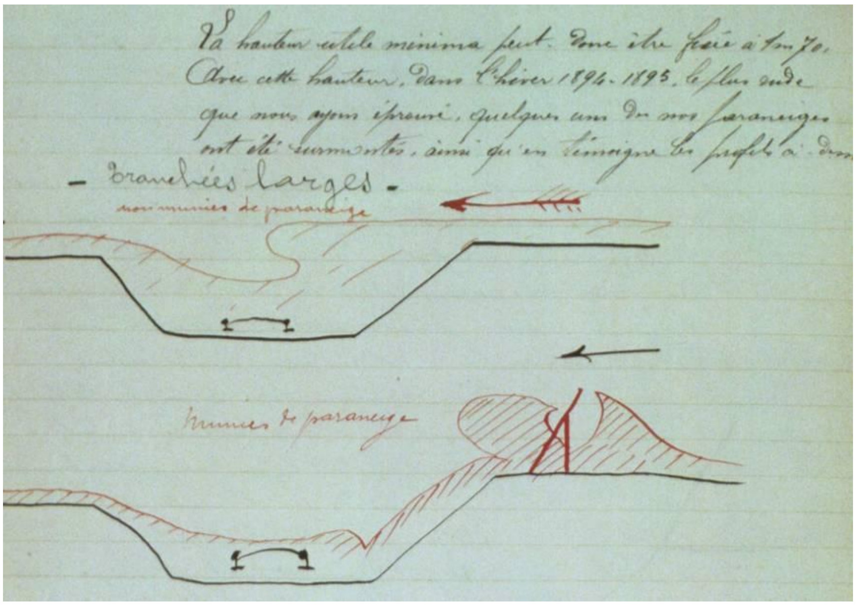


Figure 1: Extract from Morard's report (Source: Lus-la-Croix Haute station archives)

2.1 Snow fences [3-6]

The most widely studied devices for protecting against snowdrifts have incontestably been snow fences. Their operating principle is as follows: when wind blows around the highway, its flow pattern gets modified; swirling zones are formed accompanied by a drop in average wind speed. The snow swept by wind is thus deposited into these lower-speed zones located not only upwind of the fence (the term "upwind drifts" is used herein), but more importantly downwind ("downwind drifts"). The main study results are summarized in the French standard [4] entitled "Snow fence" (NF P95-305) and will be discussed below.

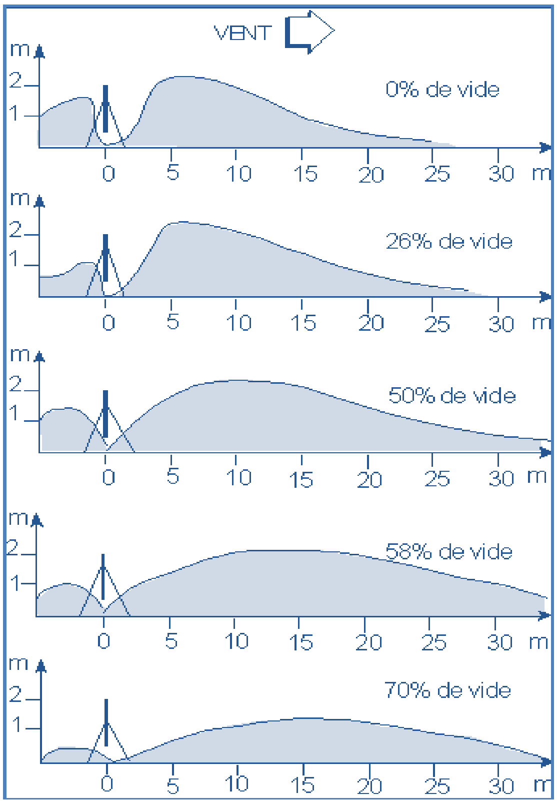
The base of a snow fence (built with spaced openings that successfully disrupt flow patterns as the wind crosses) is primarily defined by its height, bottom gap and porosity.

The porosity and bottom gap are considered optimal when for a given height, the fence yields a maximum volume of snow deposit per linear meter.

The porosity or void index is the ratio, in percentage terms, of the void surface area to the total surface area. This index directly influences the shape of snowdrifts generated by the

snow fences. As porosity increases at a given wind speed, snowdrifts become longer and thinner (Fig. 2). Optimal porosity lies between 40% and 60%.
Bottom gap is the space left unencumbered between the bottom of the panel used for fence construction and ground level. Its purpose is twofold: by accelerating the wind crossing under the fence, bottom gap yields longer and thinner snowdrifts (thus enhancing the porosity effect); and bottom gap limits the amount of snow that settles on the fence (Fig. 3).

The optimal bottom gap height equals the average snowfall in the absence of wind; accordingly, bottom gap must not be buried underneath the snow accumulation, in which case its effect would obviously be nullified.



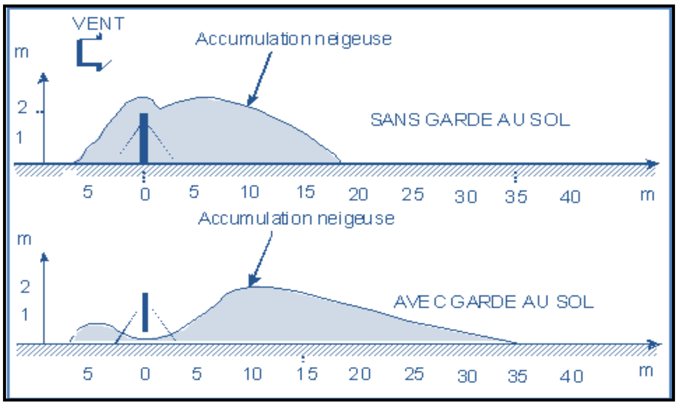


Figure 2: Effect provided by fence porosity Figure 3: Effect provided by bottom gap

It therefore appears that in order to achieve maximum efficiency, a snow fence of height H must contain a porosity of between 40% and 60% and a bottom gap height equal to the average snowfall without wind.
Under these conditions and on flat land, the snowdrift length at saturation is 25H while the accumulated snow volume at saturation is $20H^2$ per linear meter of fence.
During the installation of snow fences, several questions arise, namely: what is the appropriate height, length, direction and type of fence?
A snow fence must be long enough, in general at least 20 times greater than the fence height, to ensure limiting edge effects relative to the quantity of snow accumulated. It must be placed perpendicular to the wind direction responsible for blowing the snowdrift; fence efficiency gradually declines with deviations from this configuration. When the angle α between wind direction and fence alignment reaches 45°, the snowdrift practically disappears. For α values above 20°, fences must be laid out in a herringbone pattern (Fig. 4) so that they remain perpendicular to the dominant wind direction, yet with a sufficiently large overlap from one fence to the next. This layout yields high ratios of "fence length to length of highway to protect", though such an attractive solution is rarely chosen by facility

managers due either to a lack of familiarity or to the constraints it adds. However, this turns out to be the only efficient solution.
The need to closely examine the dominant wind direction before actually installing a snow fence is thus obvious. Moreover, the fence must be positioned far enough from the road being protected to ensure that snowdrifts do not settle on the pavement, thus adding to the difficulty of the installation. The suggested minimum fence-roadway distance is 25H (in other words, equal to the maximum length of the snowdrift created by the fence).
The advantage of snow fences is their immediate efficiency in preventing snowdrift formation, all the while their impact on visibility will remain very slight. In France, various types of snow fences are used; fences with vertical slats (made of chestnut) are to be distinguished from those with horizontal slats (referred to as CEMAGREF or Gaillard-Rondino types) and mesh fences (made of synthetic material).

2.2 Hedges and wooded snowdrift protection [7, 8]

Snow fences may be replaced by hedges. Traditionally, dense evergreen species (of a softwood variety) are used for this purpose. Given the similarity in aerodynamic function between snow fences and hedges, more porous hedges (deciduous species) may also be employed [7]. However, should hedges be incorporated into the landscape and thereby offer other advantages for flora and fauna, such a scenario would imply holding rights-of-way to all land where they've been planted (or at least it would impose an agreement with all concerned landowners) and moreover would require waiting a number of years before becoming efficient (seedlings 1.5 to 3 m tall). In some cases, planting programs can be accompanied by the installation of snow fences, which will provide immediate protection in allowing for the fully-grown hedges to take over the protective role subsequently. Keep in mind that no more than 1.5 m of snow can be allowed to accumulate on hedgerows, so as to avoid excessive pressure buildup.

Wooded strips can also serve to limit snowdrift formation by means of blocking snow upwind of the row of trees. These strips are characterized by wide and dense planting zones (at least 5 rows of softwoods or 10 rows of hardwoods). The air is captured by the woodland and gradually discharged via the treetops. On the downwind side, the protected zone extends 20 to 30 times the tree height along this strip (Fig. 4). Not only is the blowing snow intercepted and trapped by the woodland, but so are fog and mist, resulting in significantly increased visibility and consequently improving user comfort and safety. This enhanced visibility has never been quantified in precise terms. As another advantage, such use of woodland is less sensitive to wind direction than either a fence or a hedge: it proves to be efficient for an angle α ranging nearly from +90° to -90°. On the other hand, a wooded strip planted along the shoulder of a roadway can more readily lead to icy driving conditions, placing motorists at greater risk.

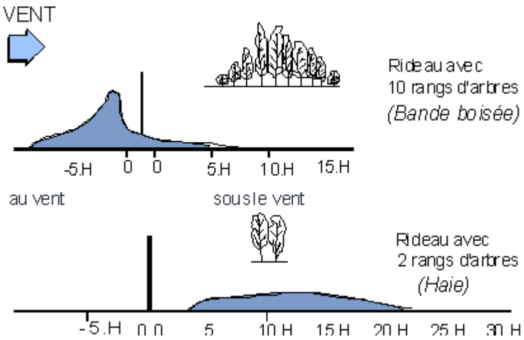


Figure 4: Profiles of snow accumulation intercepted by a row of trees

3. PROTECTION STRATEGY ADOPTED FOR THE FAGEOLE SUMMIT [1]

Following the incidents of wind-swept snow that occurred in January and February 2005, the A75 was closed to traffic for several consecutive days. It was therefore decided to install snowdrift control measures as of winter 2005-2006. Given a tight schedule between the design period and the beginning of the next winter season, snow fence installation represented the sole means available to prevent snowdrift formation, in accordance with the scope of this design study.

3.1 Winds responsible for snowdrift formation and mapping of the snowdrift zones

During the January-February episodes, an analysis of snow accumulation shapes, including data recorded by the local weather station, indicated that the winds responsible for snowdrift formation had blown from the north or northeast. In addition, a survey conducted among staff assigned to snow removal duty served to draw up a map of snowdrift zones along the A75 corridor in the vicinity of Fageole Summit. While snowdrift formation zones could be identified with precision, it was more difficult to estimate the originating wind direction. Northwesterly winds also seemed to be a plausible cause of snowdrift formation.

Not all of the mapped snowdrift zones were located in sections of slope excavation; moreover, the wind direction responsible for their formation was never exactly perpendicular to the pavement alignment. The extent of snow-covered zones combined with frequent strong wind patterns made certain configurations (which would not be deemed unfavorable in a plain setting) quite hazardous in the mountains. Since high-risk winds do not blow perpendicular to the road pavement, the snow fences were installed in a "herringbone" pattern. The so-called design winds are northerly and northeasterly. It was also necessary however to ensure that the placement of these fences did not exacerbate the risk of snowdrift formation on the pavement due to the northwesterly wind.

3.2 Choice and installation of snow fences

A study performed during the 1980's in Besse-en-Chandesse [3] had demonstrated that 2-meter high snow fences with a 30-cm bottom gap were well adapted to climatic conditions found in the Massif Central mountain range. The zones where the Fageole Summit fences were intended contained either pastureland or crop farmland; these snow fences therefore could only be modular, so as to minimize parcel damage upon their installation. During the tendering process, only one snow fence type (see Photograph 4) was able to meet these requirements. To cover the 2,600 m of fence length needed, temporary land use agreements, stipulating a €13,000 compensation, were signed with the respective landowners.

When the pavement (Fig. 5) is aligned northeast-southwest (i.e. zones A and B), the most troublesome wind direction blows from the north, meaning that the fences had to be placed to counter this wind within these two zones. As the pavement turns along a northwest-southeast alignment (zones C and D), the northeasterly wind then becomes critical. In these zones, the fences were thus installed to face the incoming northeasterly winds. Even though it had not been referenced for snowdrift formation, zone E was still fitted with fences since the low-height excavation profile on the southward section after the curve plus its southeast-northwest pavement alignment made this zone potentially vulnerable to the northerly wind. Subsequent observations justified our concerns (Fig. 7).

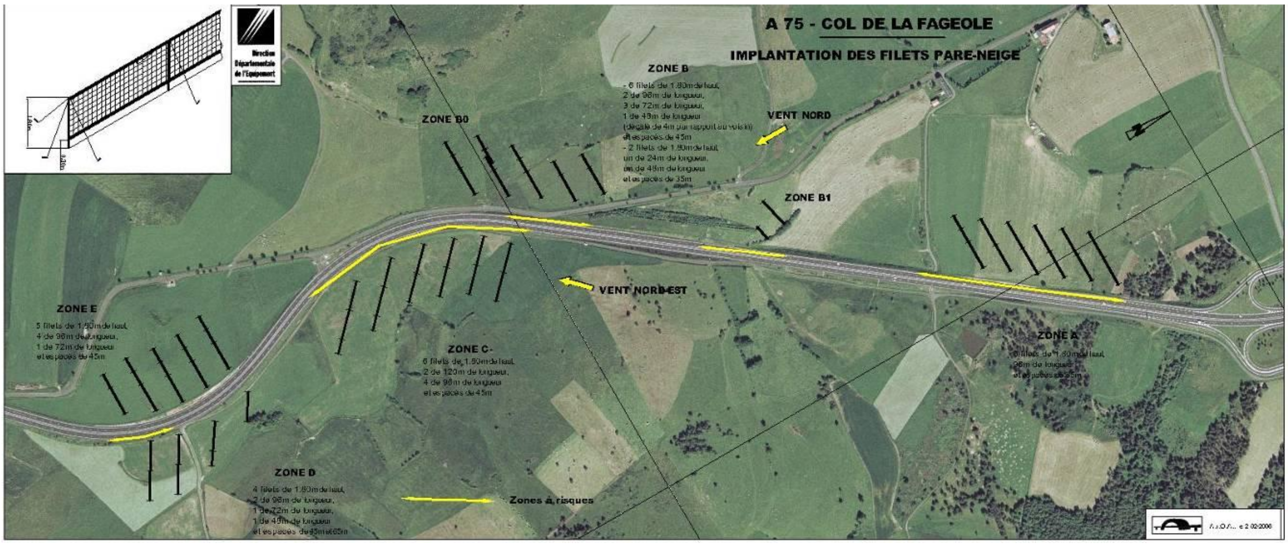


Figure 5: Identification of high-risk zones and protection measures proposed in 2006

In 1990, problems related to snowdrifts had already been raised on then national highway RN9 in the vicinity of the Fageole Summit. RN9 was initially protected by a line of snow fences that at the time were replaced by a 260-m long wooded strip composed of 4 to 6 rows of common spruce trees (Picea Pungens), mountain pines, black pines, broom, alders and hazel trees [9] (Photograph 5). Twenty years later, RN9 became the A75 motorway and the wooded strip now located 25 m from the pavement is fulfilling its function. As will be explained below however, it is beginning to show signs of aging.

Photograph 4: Fageole Summit snow fence (Source: IRSTEA Institute)

Photograph 5: Fageole Summit wooded strip (Source: IRSTEA Institute)

4. MONITORING AND EVOLUTION OF THIS PROTECTION SYSTEM [10]

A monitoring program was implemented by A75 facility managers and the IRSTEA Research Institute through 2010. The January 2005 incident did not recur with the same intensity. The most significant incident in terms of providing valuable insight took place in February 2010 and allowed identifying new zones of snowdrift formation. These site visits led to improving the protection system presented in Figure 7.

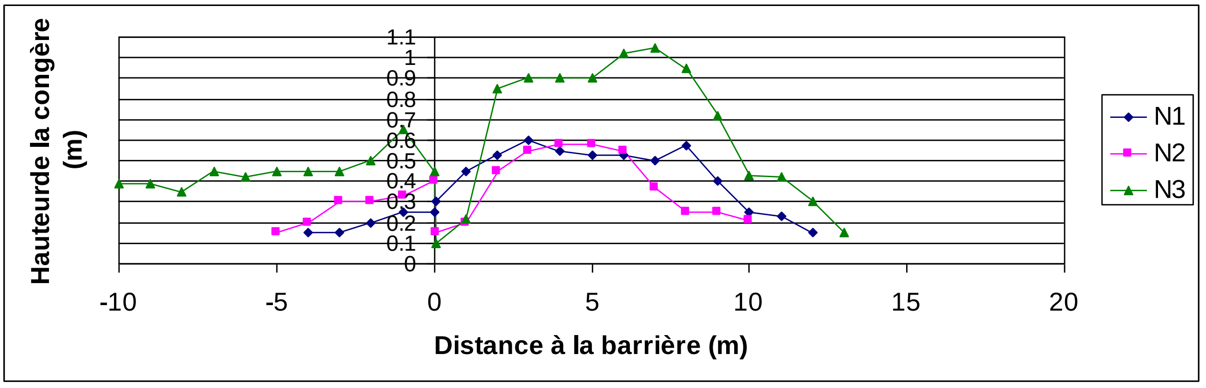
4.1 Winds responsible for snowdrift formation

It has been confirmed that the winds responsible for snowdrifts blow from the north and northeast. A northwest and, in some cases, southeast component has also been recorded. A specific characteristic of the Fageole Summit (observed on January 2nd, 2006) is most edifying and merits mention here. The northwesterly wind at the beginning of the day turned northerly and then northeasterly by the end of the day. The average wind speed was 23 m/s (83 km/h), with a maximum recorded speed of 43 m/s (155 km/h)!
Strong wind intensities sometimes serve to limit the efficiency of porous fences compared to denser natural obstacles. The recommended spacing of 25H found in the snow fence standard has since been lowered to 20H.
Winds that blow roughly parallel to the pavement continue to cause problems. During winter 2006-07, the accumulation of snow between the wooded strip and the A75 (Photograph 8) wound up forming a snow bank on the slow lane around zone B0 (at the transition in the road's radius of curvature). The installation of snow fences placed perpendicular to the wooded strip mitigated this nuisance.

4.2 Resistance of the snow fences

During the first year, following a climatic episode involving freezing fog at the end of December, some of the nets fell from their supports. The firm was called in for repairs, and this resulted in the design and installation of a system of so-called *antifreeze hooks* to provide additional reinforcement. Over time, other nets have been damaged to an extent that requires replacing on average 15% of total fence length each year, but on the whole the series of fences have performed well. It should be underscored that in order to achieve maximum efficiency, the fences must be inspected during the winter period and re-tensioned (Photograph 6).

Photograph 6: Fences sag and tear when not adequately tensioned.



Texte : Snowdrift height (m), Distance to the fence (m)

Figure 6: Example of snowdrift shape, February 16th 2010 / zone N - height recordings of snow fence B11 (Source: IRSTEA Institute)

4.3 Benefit derived from the wooded strips

As of the first monitoring campaign conducted in 2006, the benefit of the wooded strips was unmistakable. The efficiency of snow fences is highly sensitive to this site's variable wind patterns (ranging from northwesterly to northeasterly). The planting of a wooded strip, like that installed in zone B, is more efficient due to its lower sensitivity to wind direction. During these winter monitoring campaigns, especially winter 2007-08, another factor in favor of wooded strips came to the fore. The characteristics of snow fences (in particular porosity and bottom gap) are dictated by the NF P95-305 Standard, which stipulates an optimal porosity lying between 40% and 60%, as this range allows accumulating a maximum volume of snow for an average strength wind. When the winds gust, as was the case in 2008, this threshold decreases. To this day, no theoretical studies have been conducted or physical wind tunnel models built that enable optimizing the porosity value vs. a reference wind speed. Nonetheless, for this episode displaying a 3-day average wind speed of 10 m/s with a maximum of 22 m/s, the fences proved to be rather inefficient. On the other hand, a wooded strip is less sensitive to violent wind gusts; moreover, motorists' visibility will be better in a zone protected by woodlands than one relying on fences (a non-quantified empirical assertion).

A wooded strip however also requires regular maintenance, and this aspect had been neglected in the case of the A75, leading to a degraded condition. The February 2010 incident actually exposed that undergrowth on the wooded strip was no longer thick enough, which allowed snow to penetrate, resulting in the formation of downwind snowdrifts. This situation can be explained by the fact that the softwoods planted in the woodland had thinned out at their base due to excessive competition (light needs to reach the base of trees in order to keep the lower branches alive). The efficiency of a wooded strip option depends in fact on maintaining just the right density of lower branches. To avoid this risk of natural pruning on the lower branches, it is suggested (depending on the species' growth) to proceed with a controlled thinning that consists of removing every other tree. It would also be advised to plan on replacing these softwood strips by planting shade conifers (silver fir) or beech instead of cut seedlings. Such a renewal program would allow these seedlings to constitute a lower layer that in time would replace the originally planted softwoods. This woodland management approach is essential to avoiding the problem of natural thinning and the risk of woodland loss after a storm for example.

Photograph 7: February 16th 2010 / Zone located east of the wooded strip:
Snowdrifts forming downwind of the woodland.
The red arrow indicates wind direction (Source: IRSTEA Institute)

4.4 State of the A75 protection system in 2012

The observations recorded over the course of several winter seasons, which provide the basis for the present study (though all too often overlooked during field work), have improved the state of knowledge of site aerology in addition to enhancing the *in situ* protection system (Fig. 7). The benefit of woodland protection against snowdrifts has also been demonstrated. All elements are therefore in place to seek a more durable and more efficient solution better adapted to the local landscape and that, in the long run, will prove less expensive, as the compensation and costs associated with installing and removing the nets amount to approximately €35,000 a year.

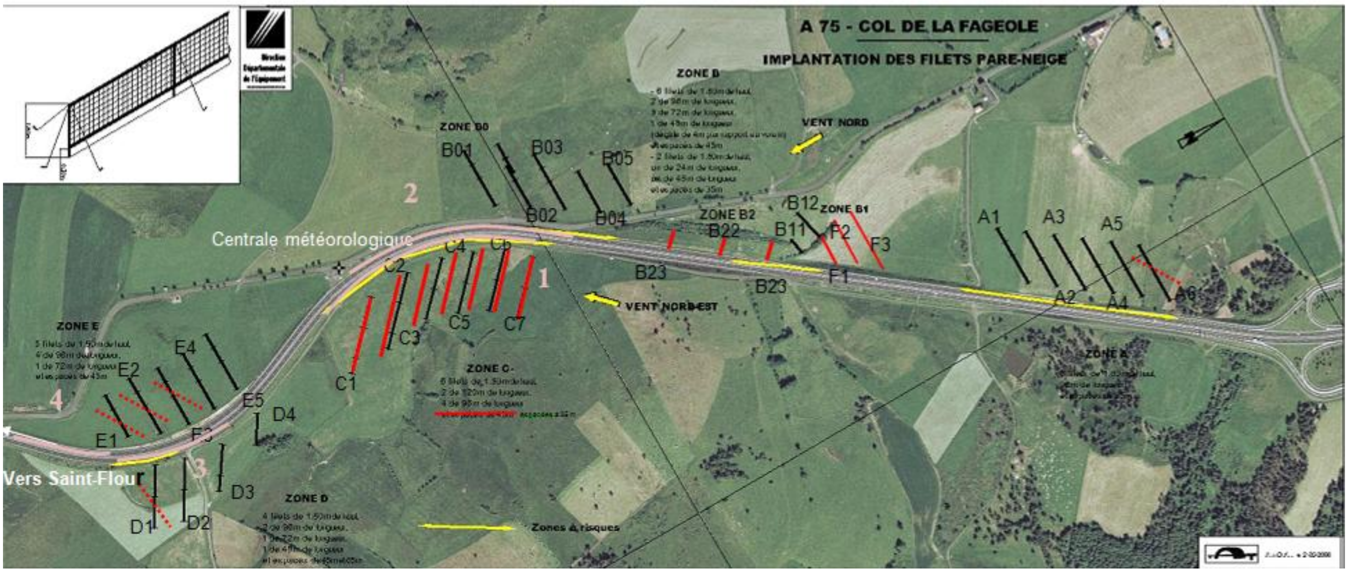


Figure 7: Identification of high-risk zones in 2005 (shown in yellow); location of protection system components proposed in 2005 (black), then modified in 2007 and 2008 (red). The red dashes indicate those fences removed and transferred to other zones. Snowdrift formation zones identified after the February 2010 incident are highlighted in pink.

4. LOOKING TOWARDS A NEW PROTECTION DESIGN

The set of specifications adopted by the DIR Massif Central Office included the following:

- Snowdrift protection must consist of hedges and/or wooded strips.
- A75 snowdrift protection components must not lead to additional snowdrift formation on the highway (compared to the situation in January 2005).
- Before reaching their optimal tree height, the wooded strips must not exacerbate snowdrift formation on the A75 (compared to the January 2005 situation) while not necessarily requiring the installation of snow fences. This specification is thus interpreted as tolerating a situation like that encountered in January-February 2005 during the woodland growth period.

These constraints have led to the set of recommendations depicted in Figure 8.

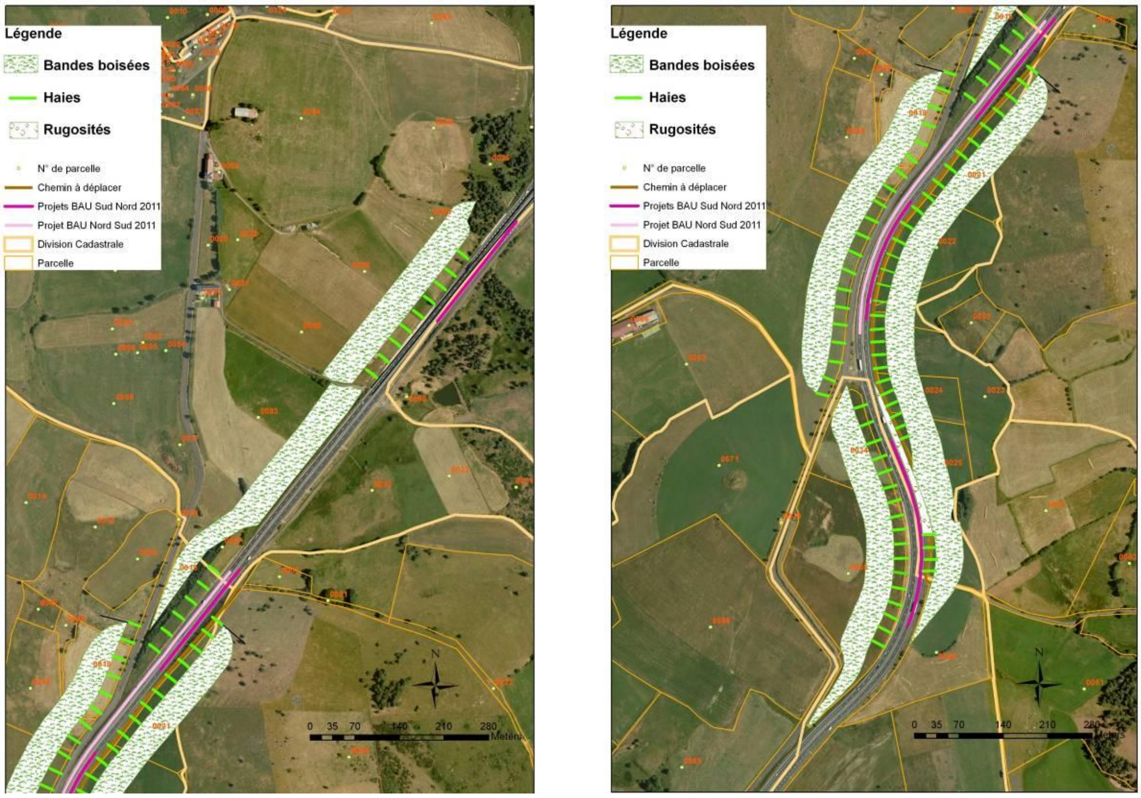


Figure 8: Proposed use of vegetation as snowdrift protection over the northern (left) and southern (right) zones

The major guidelines call for:
The wooded strips are to be located 20 m from the road pavement in order to:

- limit the ice formation,
- avoid the formation of snowdrifts on the pavement during the woodland (trees and shrubs) growth period (should wooded strips be placed 4-5 m from the pavement, they would initially behave similarly to the hedges and become responsible for generating snowdrifts),
- prevent the formation of snowdrifts on the pavement beyond 20 or 30 years in the event of poor maintenance (should the woodland be located 4-5 m from the pavement and the lower branches no longer perform their function, the risk would be incurred of snowdrift formation downwind of the strip, see Photograph 7).

These wooded strips are to be complemented by hedges running crosswise, with the intent of diminishing the influence of winds blowing practically parallel to the pavement, thereby creating snow traps to limit pavement erosion. Adaptations to this layout must take into account local topographic conditions.

Photograph 8: January 30th 2007 / Zone located between the A75 and the wooded strip: the snow has been eroded (Source: IRSTEA) - the arrow indicates wind direction.

The wooded strips to be introduced will be wider than the current one planted 20 years ago (which measures 20 m wide, with 5 or 6 rows of trees).
Why this change in width? The objective herein is to ensure durable efficiency with long-term applicability, which is not the case for the existing strip due to its limited number of rows. The long-term management of a woodland is complicated by the need to replant the softwoods every 30 to 40 years. The current woodland does not allow for such a renewal program since cutting and replanting several rows of trees while maintaining an efficient level of snow protection from the remaining rows tends to be infeasible.
We are therefore proposing a greater woodland coverage (50 m being the ideal width and 40 m the absolute minimum), which would make it possible to plant between 10 and 13 rows of trees. A regular renewal program, progressing by strips of 3 to 4 rows at a time, will be simple to set up on a long-term basis.

5. CONCLUSION AND FUTURE OUTLOOK

Subsequent to two consecutive incidents involving wind-blown snow causing closure of the A75 motorway during January and February 2005, the decision was made to install snow fences. Their orientation, which turned out to be highly sensitive to wind direction, gave rise to an analysis of meteorological data recorded by the Fageole Summit weather station, in combination with a field survey conducted among staff with the Regional Roads Directorate (DIR). This work led to an initial set of proposals regarding fence location over a segment of more than 2 km. For 6 years, this protection system was monitored and upgraded. However, since the efficiency of snow fences turned out to be very sensitive to wind direction in addition to generating high operating costs, it quickly became apparent that the planting of wooded strips would offer an improved solution. The experience acquired during these snow fence monitoring campaigns enabled proposing a layout that in the long run will provide efficient protection against snowdrift formation.

REFERENCES

1. Naaim-Bouvet F. (2006). Implantation de barrières à neige au Col de La Fageole. Rapport d'expertise pour le compte de l'arrondissement interdépartemental des ouvrages d'art de l'A75,, 35 p.
2. Serre F. (2001). La neige dans le massif central. Presses Universitaires Blaise Pascal, Clermont-Ferrand, 2003 p.
3. Naaim-Bouvet F. et M. Naaim (2000). Transport de la neige par le vent : Connaissances de base et recommandations», dans La Neige : Recherche et Réglementation, Presses des Ponts et Chaussées/ Cemagref Editions, 2000, pp. 65-151.
4. NF P95-305 Décembre 1992, Équipements de protection contre les avalanches – Barrière à neige – Spécifications de conception.
5. Naaim-Bouvet F. et M. Truche (2014). Guide ouvrages à vent paravalanches. URL : http://www.avalanches.fr
6. Naaim-Bouvet F. et M. Truche (2013). Guide technique « Ouvrages à vent en zone de montagne », Proceedings de l'International Snow Science Workshop, 7-11 Octobre 2013, Grenoble-Chamonix Mont-Blanc.
7. Naaim-Bouvet F. et P. Mullenbach (1998). Haies pare-congère : Etude expérimentale in situ. Revue forestière française, n°3, pp. 263-276.
8. Naaim-Bouvet F., Monier S. et S. Ougier (2010). Haies et boisements pare-congères : de la théorie à la pratique. Revue SET, 2010, no. 02, pp. 78-89. URL :http://www.set-revue.fr/haies-et-boisements-pare-congeres-de-la-theorie-la-pratique
9. Naaim-Bouvet F., Monier S. et S. Ougier (2010). Focus : Bande boisée du Col de La Fageole. Revue SET, no. 02, pp. 90. URL :http://www.set-revue.fr/focus-bande-boisee-du-col-de-la-fageole
10. Naaim-Bouvet F. et S. Monier (2013). Propositions d'implantations de plantations pare-congères au col de La Fageole, rapport d'expertise pour le compte de la DIR Massif Central, 46 p.