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17TH INTERNATIONAL ROAD WEATHER CONFERENCE IN ANDORRA

Impact of natural hazards on the roads of Andorra
Historical database analysis (1933-2000)

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Introduction

Natural hazards are quite present in a mountainous country like Andorra, of only 468 km² in the Pyrenees. They affect everything on their way, such as landscape, people, buildings, roads, etc. and they can cause significant damage, and even, in the worst cases, fatal victims. As far as the Andorran roads are concerned, which are the main communication routes in the country, it's vital for roads managers to be aware of the natural hazards that affect them. This information can help to take measures for preventing those natural hazards and minimizing their impact on the roads of the country.

Historical database analysis

The analysis of CENMA's historical database of natural hazards, based on press news and Police and Fire Brigades reports, points out that from 1933 to the year 2000 the five most frequent natural phenomena that have affected the roads of the country were: rock falls, tree falls, snowfalls, floods and landslides. Concerning the main meteorological phenomena associated (which were often the triggers), there was mainly rain and wind (figure 1).

Talking about fatalities, the most frequent phenomenon is not the one that caused more victims. Indeed, during the study period, Andorra lamented a total of 18 deaths caused by natural hazards impact on roads, which 13 of them were victims from one single episode of flood in 1982 (figure 2).

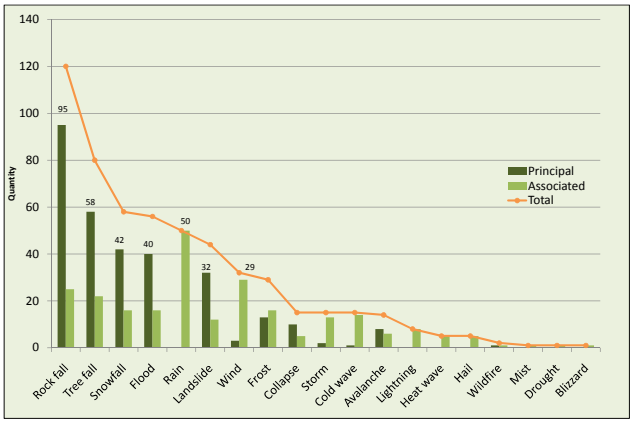

Figure 1. *Distribution of the 551 natural hazards that affected Andorran roads from 1933 to the year 2000, according to the Andorran press news and Police and Fire Brigades reports. For each episode, CENMA's database has considered a single principal hazard, and the others phenomena as associated hazards. For example, in the case of a storm that caused a flood, the flood has been considered as the principal hazard (the phenomenon that has caused damage) and the storm as an associated hazard (in this case, the triggering meteorological phenomenon).*

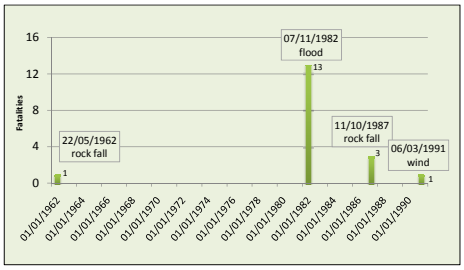

Figure 2. *Episodes of natural hazards that have caused fatalities on Andorran roads from 1933 to the year 2000.*

Figure 3. *Rock fall affecting a road of Andorra la Vella in April 2008.*

According to CENMA's database, rock fall is the most frequent phenomenon that have affected Andorran roads (figure 3). It seems to be reasonable in a country with so much altitudinal gradient, where roads go from about 850 meters (border with Spain) to 2,400 meters of altitude (Port d'Envalira, near the border with France) in just 40 kilometers. However, it has to be in mind that this database is not exhaustive regarding the impact of natural hazards on roads, such as, for example, snowfalls in the country not always appear on press news, whereas they are probably the phenomenon that request more financial resources and dedication from the Andorran roads managers, as it is a phenomenon that affects roads on a much larger spatial scale.

2012-2013 season, an exceptional winter

Even if they are not part of the study period (1933-2000), it is worth mentioning the several episodes of significant snowfalls suffered in Andorra last winter (figure 4). Due to the high risk of avalanche, some evacuations in urban areas were needed. Moreover, there was a large increase in the cleaning tasks of the country road network. Examples of those important actions taken on the roads have been significant increases in the annual budgets for roads cleaning tasks, either by increasing the distance covered by snow blowers, by buying tons of extra salt to minimize frost, or for external recruitment (table 1).

Throughout the winter season 2012-13, in Sorteny and Bony de les Neres weather stations were recorded up to 58 days of precipitation higher than 2 mm (table 2) and snow depths in the ski resorts were very important: 6 m in Pal and Arinsal, 8.5 m in Grandvalira and 9 m in Arcalís (figure 5).

Figure 4. *Some images of the snowfalls and cleaning tasks of the 2012-13 winter season.*

Figure 5. *Territorial division of Andorra in 7 municipalities and location of weather stations of Bony de les Neres and Sorteny. Snowflake symbols correspond to ski resorts: 1. Pal, 2. Arinsal, 3. Arcalís and 4. Granvalira.*

Municipality	Planned budget	Budget increase	Final costs	Coefficient multiplier	Salt increase	Description
Canillo			**> 100,000 €**	**2**		Overtime workers of the municipality
Encamp	25,000 €	39,500 €	**64,500 €**	**2.6**		External recruitment
Ordino	7,500 €	43,440 €	**50,940 €**	**6.8**		External recruitment
La Massana	32,500 €	25,389 €	**57,889 €**	**1.8**		
Andorra la Vella		22,000 €				External recruitment
Sant Julià de Lòria		4,000 €			10 tons	Ten tons of extra salt
Escaldes-Engordany	0 €	0 €	**0 €**			No specific budget

Government	Planned budget	Budget increase	Final costs	Multiplier	Salt increase	Description
Andorra	300,000 €	0 €	**300,000 €**		500 tons	Budget not altered although more distance traveled by vehicles and more salt bought (5,000 instead of 4,500 tons)

Table 1. *Increase annual budgets dedicated to roads cleaning tasks associated with snowfall during the winter season 2012-13 (data from Andorran press news). In Andorra, the Government is responsible for the cleaning of the national road network, and each of the 7 municipalities (figure 5) is responsible for the cleaning of its secondary roads and streets. Andorra la Vella, Sant Julià de Lòria and Escaldes-Engordany are the three municipalities where it snows less.*

Weather station	Bony de les Neres			Sorteny		
Month	**Days**	**Precipitation (mm)**	**Climatic anomaly**	**Days**	**Precipitation (mm)**	**Climatic anomaly**
December 2012	6	51.1	58 %	7	45.6	45 %
January 2013	16	170.4	239 %	10	78.9	94 %
February 2013	10	163.9	317 %	12	107.5	170 %
March 2013	16	107.4	194 %	18	105.8	159 %
April 2013	10	95.7	100 %	11	98.9	89 %
TOTAL	**58**	**588.5**	**162%**	**58**	**436.7**	**103%**

Table 2. *Days of precipitation, monthly totals accumulated and monthly mean precipitation anomalies (period of reference 1971-2000) at weather stations of Bony de les Neres and Sorteny (data from CENMA's weather stations and from the Digital Climatic Atlas of Andorra). For example, in February 2013, in Bony de les Neres it snowed more than 3 times than usual (climatic anomaly of 317%). While in Sorteny the whole winter season was climatically normal (climatic anomaly of 103%), in Bony de les Neres it was considered climatically wet (climatic anomaly of 162%).*

References

- *Andorran press news from 1933 to 2000, and from December 2012 to April 2013 (Diari d'Andorra, Periòdic d'Andorra, BonDia Andorra, Més Andorra)*
- *CENMA's database of natural hazards (www.cenma.ad)*
- *CENMA's weather stations data (www.cenma.ad)*
- *Digital Climatic Atlas of Andorra (www.acda.ad)*
- *Reports of Police and Fire Brigades from 1933 to 2000*
- *Ski resorts data of 2012-13 winter season (www.grandvalira.com and www.vallnord.com)*

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