Avalanche Risk Estimation and Hazard Zoning in Iceland

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Photo: Emil Tómasson, February 2008



Outline

- Background of the current hazard mapping method in Iceland
- The Icelandic method of estimating risk
- Further developments

The background of hazard mapping in Iceland

- After a fatal avalanche accident 1974 in Neskaupstaður the first hazard maps were made by local authorities

 no regulations
- The first laws were set in 1985 after an accident in Ólafsvík

1994-1995

- 36 people were killed in four avalanche accidents
- Many of them were in houses located in "safe" zones according to hazard maps at that time
- A discussion started of what is acceptable in terms of avalanche return periods and avalanche risk
- The government decided to provide funds for avalanche research, hazard mapping and defences/resettlement

What is acceptable?

Imagine an individual living in a house for 75 years, where the return period of avalanches is 300 years

- 20-25% probability of an avalanche hitting the house while he/she lives there
- Avalanche risk is much greater than any other factor, e.g. diseases or other accidents

New method

- In the years 1996-1999 a new method of hazard mapping was developed in Iceland
 - based on individual risk

Individual risk vs. return periods

- The severity of an avalanche event may depend on several other factors than its return period
- Is it possible to select acceptable return periods without estimating risk?
- How should one compare return periods of avalanches to slush flows, debris flows, rockfall?
- Individual avalanche risk is directly comparable to various risks – other natural disasters, traffic, disease

Acceptable risk

Defining acceptable risk should not be considered a technical problem

It is a political issue !

Risk – Annual probability of death

Some risk factors

- earthquakes in Iceland: 1 out of 1 000 000 ?
- traffic: 1 out of 10 000
- airplanes: 0.5 out of 1 000 000 trips
- children 1–15 yr (all causes): 2 out of 10 000
- avalanches 1900-2000 in avalanche prone
 - villages in Iceland: 5–10 out of 10 000
- Acceptable risk by avalanches in Iceland
 - 0.2 out of 10 000 per year

Local risk

- Acceptable risk is defined by a regulation as 0.2 out of 10 000 per year for an individual inside an ordinary house
- We assume that any person stays only 75% of the time over a whole year in a particular house. Therefore, it is acceptable for a house to be located where the risk is 0.3 out of 10 000

Hazard zoning

- Areas of unacceptable risk are classified into three categories:
 - Zone A 0.3-1.0 out of 10 000 per year
 - Zone B 1.0-3.0 out of 10 000 per year
 - Zone C > 3.0 out of 10 000 per year
- Local authorities are required to either defend or relocate settlements in Czones



Authorities

- The Ministry of the Environment is responsible and provides funds
- The Icelandic Meteorological Office is responsible for
 - risk assessment
 - snow observations
 - evacuations
- Local authorities are responsible for building defense structures

Avalanche hazard zoning for 16 villages



Elements of risk calculations

- Transfer between paths Runout indices
- Relative tail-shape of the runout frequency distribution
- Estimation of a base frequency
- Speed profiles and survival rate

The standard path

- Transferring avalanches between paths using a physical model
- The calculation of runout indices in a standard path
- Watching 50 independent standardized paths for 80 years can be considered like observing avalanches in a single path for 4000 years

Possible flaws

- Hillsides with frequent avalanches may have different shape of frequency distribution (FD) than low frequency hillsides
- Not all avalanches have been (accurately) recorded
- Different paths may have special characteristics (Climate, 2D landscape, PP of snow) affecting the relative shape of the local FD
- Climate change The climate variability for the 20th century may not fully represent the 21st century







196 Icelandic avalanches





Speed profiles



Survival rate



Súðavík













Súðavík



Further developments

- Calculation of 2D runout indices
- Reevaluation of the shape of the runout frequency distribution
- Define better the survival rate function
- Integration of the total risk
- Comparison between countries

2D runout indices

- The runout index scale has been used extensively at IMO
- Flow-line models only consider the geometry of the path in the downstream direction
- In reality topographical features such as gullies and ridges strech along avalanche paths and affect the runout of avalanches
- It is possible to use 2D models to estimate 2D runout indices for hazard mapping

2D standard path



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