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Climate and transport

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Deliverables

Reports

The programme has published 38 reports (in Norwegian), on all working topics of the programme. All reports and a number of conference papers can be downloaded from the programme website: www.vegvesen.no/klimaogtransport.

Proposals for revision of guidelines

The NPRA publishes and maintains a series of manuals, which incorporate international and national standards and guidelines for best practice for Norwegian roads. One of the aims of "Climate and Transport" has been to provide proposals for revisions of and supplements to these manuals. The majority of these proposals has already been implemented or is on its way to be implemented.

New guidelines on four important topics

New manuals are proposed on the following topics: 'Rockslide protection of roads', 'Debris flows and slush avalanches', 'Roads and snow avalanches', and 'Roads and drifting snow'.

Web portal

A web portal combining weather data (historical, present and forecast), ground and road data, events on the road network and threshold values for nature hazards has been developed in cooperation with the National Rail Administration and Norwegian Water Resources and Energy Directorate, see www.xgeo.no.

Draft of a landslide risk model

A first version of a risk model has been developed. In the risk model, landslides and avalanches are described by factors affecting the probability and consequences. The factors represent exposed terrain, geological conditions, weather conditions, traffic amount and others. This work is in progress.

"Climate and transport" is a research and development programme carried out by the Norwegian Public Roads Administration. The programme was initiated in January 2007 and the final report submitted in May 2013. The main objectives of the programme have been to investigate the effect of climate change on the road network and recommend remedial actions concerning planning, design, construction and maintenance. The aim is to sustain both safety and accessibility in a more demanding climate.



Photo: Knut Oppeida

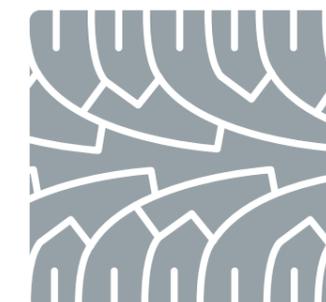
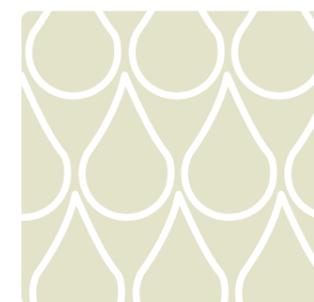
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www.vegvesen.no/klimaogtransport



Climate and transport



BACKGROUND

The future climate in Norway is expected to be warmer and wetter. There will be more frequent and intense rainfall, milder winters, warmer summers and an increase in wind speed and storm frequency.

This will affect the road network in several ways. There will be a higher risk for floods and erosion, and a higher risk for landslides and avalanches. Slides may occur at new locations and we may experience an increase in so called “wet” slides, such as slush avalanches and debris flows. Areas used to stable winter conditions may experience higher exposure to repeated freezing and thawing. Reduced accessibility and regularity on the road network should also be expected. All this requires improved contingency plans.

These were the reasons for initiating “Climate and Transport”. It was necessary to investigate if design specifications needed revision, if existing protection measures were sufficiently safe. The programme was carried out in close cooperation with the Norwegian National Rail Administration, and with the help of a large number of cooperating partners, such as the Norwegian Coastal Administration, Avinor (the Norwegian organisation responsible for air traffic control and services), Norwegian Water Resources and Energy Directorate, Norwegian Geological Survey, Centre for International Climate and Environmental Research (CICERO), Norwegian Meteorological Institute, Directorate for Civil Protection and Emergency Planning, Norwegian Geotechnical Institute, Norwegian University of Science and Technology NTNU /SINTEF and Norwegian Institute for Agricultural and Environmental Research.

The Norwegian Climate Centre published in 2009 the report “Climate in Norway 2100”. This report provided the R&D programme with knowledge about the anticipated climate changes the Norwegian road network will have to adapt to.

THE PROGRAMME CONSISTED OF THE FOLLOWING WORK PACKAGES:

WP1

Programme conditions and demonstration projects is a work package where topics of general importance for the programme as a whole were dealt with: new climate research, design values for floods, sea level etc. It also coordinated the full-scale demonstration projects carried out in other work packages.

WP2

Data: Collection, Processing and Storage had the aim to improve accessibility and coordinated utilisation of data relevant for climate adaptation. WP2 also explored new methods and tools for dynamic presentation of weather and climate data, combined with data concerning ground conditions, road data and events on the road network.

WP3

Flood and Erosion Prevention focused on principles for the choice of structural solutions and methods for design and maintenance of drainage and erosion protection measures. The work included drainage systems, erosion of slopes, bridge foundations, and erosion from waves. It also looked into environmental aspects of climate change.

WP4

Avalanches and landslides dealt with all types of avalanches and how their frequency and triggering factors can be influenced by climate change. The main topics were: methods for description of probability and risk and definition of risk acceptance criteria; mitigation and protection plans; methods of physical protection. Special attention was given to slush avalanches and debris flow.

WP5

Bearing Capacity of Roads studied the impact of climate factors on deterioration of roads. The aim of this work package was to model deterioration of road pavements in the future climate and calculate costs for maintaining the present road standard. In addition to roads with asphalt pavements, gravel roads were included in the study, due to their importance for the county and forest road network and their susceptibility to climatic conditions.

WP6

Consequences for Winter Operation investigated necessary measures for maintaining traffic safety and regularity in extreme winter conditions concerning snow, wind, and temperature changes. Important topics are maintaining acceptable friction conditions and adapting strategies for winter operation in zones with shifting climatic conditions.

WP7

Susceptibility and Emergency Plans included development and application of suitable risk- and susceptibility analyses, adaptation of emergency systems to more variable weather conditions and implementing relevant changes in operation and maintenance contracts.



ADAPTATION MEASURES: PROPOSED, IMPLEMENTED AND UNDER PLANNING

Planning, design and construction

- The effects of climate change should be considered as an integrated part of the planning and development of a road project. Whenever possible, the road should be placed in areas less prone to landslide and flood hazard, or where this hazard is easier to handle. Special attention should be given to crossing waterways. These requirements have been included in NPRA guidelines for planning and conducting of road projects.
- The NPRA guidelines require 200-year flood level as design level for road elevation. An additional safety margin should be chosen, depending on e.g. redundancy and the quality of the input data. Sea level rise and increasing storm surge levels must also be taken into account.
- A plan for storm water management shall be established in new road projects. It is strongly recommended to plan for drainage solutions that cover a larger area and include alternative flood ways, retention ponds, protective ditches on slopes and cuts.
- A climate factor (greater than 1 but not of fixed value) has been introduced as a safety factor, in the procedure for calculating the necessary capacity of culverts and drainage pipes. In addition, the calculation shall be based on the newest available data and statistics.
- The design requirement for bridges, including design of erosion protection and free height over water, is the 200-year flood water levels and flood loads. It is also recommended to perform a risk analysis with respect to 1000-year flood conditions in order to avoid catastrophic consequences, such as loss of life or loss of the entire structure.

Operation and maintenance of existing roads

- Considering impacts of climate change should be a part of all work processes. Adaptation measures should preferably be carried out as part of scheduled maintenance.
- An inventory of vulnerable assets should be carried out to provide the basis for assigning priorities. For assets identified as vulnerable, more detailed analysis is required – including collecting improved meteorological and hydro-

logical data, more detailed calculations of capacity. “Climate and transport” has proposed guidelines for such inventories and analyses.

- Landslides are a well-known challenge for Norwegian roads. Approximately 2000 landslides hit the road network every year. Climate change aspects have been included in the model used for comparing landslide risk for roads and prioritising protection measures. In addition, three new guidelines have been published: for protection against rock fall (the most common slide type in Norway), for managing snow avalanches and for “wet” landslides, i.e. slush avalanches and debris flow.
- Operation contracts shall be composed in a way that climate change considerations are included in the description of all tasks and also in defining “standard” weather conditions.

Preparedness and improved emergency plans

- A system for “stepwise preparedness” has been further developed during the R&D programme. In challenging weather situations, the conditions are followed closely and preparedness level elevated accordingly. For each level (green, yellow and red), tasks and responsibilities are defined. Remedial measures are set in before excessive damage happens. “Climate and transport” proposes the implementation for this system as standard for preparedness against avalanches, floods and other natural hazards.
- Web portal www.xgeo.no is recommended as a tool for risk assessment and preparedness. The web portal presents current weather data related to calculated threshold values for flood, landslide, snow avalanches, etc.
- An improved template for an emergency plan for natural hazard has been formulated and is being implemented in operation contracts. The plan includes more elaborate use of weather data and map-based information concerning the specific road stretch.
- Operation contracts shall ensure preventive maintenance with special focus on open waterways and avalanche warning. Training of contractors shall include new knowledge on climate change and tools for better risk management.

Developing a knowledge base for adaptation

- Roads and railways, also sea and air transport, have many common challenges associated with climate change, it is only reasonable to cooperate. However, adaptation of transport infrastructure to climate change is dependent on expertise provided by other professional sectors. Good communication with experts in meteorology and hydrology is essential for interpreting and adapting results of climate research for practical engineering purposes.
- Improved monitoring of climate parameters (e.g. rain intensity and wind), more detailed flood data and analysis (especially for small catchments), merging and development of common databases (e.g. national landslide database www.skednett.no) – all this will provide a better basis for coping with future challenges.

Adaptation to climate change is a long-term national effort.