Assessment of Road Equipment Resistance to Snow Plough Loads

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Sognefjell National Route, Photo: Jarle Wæhler / Statens vegvesen


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0. CONTENT: Assessment of Road Equipment Resistance to Snow Plough Loads

1. Introduction
2. Historical background
3. Published standard and future improvements
4. Remarks and conclusions

Historical background

Introduction

- Damages to safety barriers caused by snow operations are an issue for only few countries in the world.
- Very few researches and financed projects have been conducted on this subject.
- In the paper the historical background of today's standard classification is analysed by decades:
  - The 90's: collecting experience;
  - The 00's: studying the subject and evaluating possible classification's methods;
  - The 10's: Including the resistance to snow plough load in the European standard.

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Historical background

Collecting experience: general

Safety barriers:

- tend to collects drifting snow.
- can be exposed to high vertical and horizontal forces caused by snow plough vehicles and by the weight of the snow.
- need greater maintenance in areas subject to snowfalls.
- have a shorter durability than barriers used in areas with a milder climate.

- design does not focus on forces caused by snow and winter maintenance vehicles.
- durability can be increased by improving the barrier design.

Durability of guardrails in Northern Europe / ROADEX

Historical background

Collecting experience: different types of safety barriers

- W types
- Pipes Box-beam
- Wire rope






Historical background

Collecting experience: different types of damages

- Flattening of the rail

- Yielding of the rail

- Rusting

- Bending or impairment of the posts

Historical background

Studying the subject

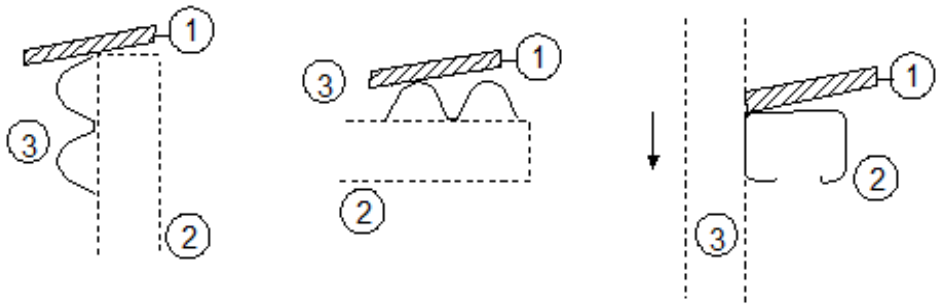
- Experimental tests
  - Drop test
  - Quasi-static tests
  - Simulation of snow clearing
  - Exposure tests

- Evaluation methods
  - Control equation
  - Design based
  - Snow bank static load

Historical background

Impact tests to assess safety barriers performances to snow plough loads

- Drop test
  - Multiple impacts on safety barrier components.
  - The notch caused by the blade is measured and classified.



1-impacting blade; 2-barrier's post; 3-barrier's rail

Conclusion:

- Safety barriers can be classified according to the notch depth.
- Snow plough loads can generally deform a standard 3mm rails.

Historical background

Impact tests to assess safety barriers performances to snow plough loads

- Quasi-static loading test
  - Single test on a installed safety barrier.
  - The deformation/displacement is measured and classified.



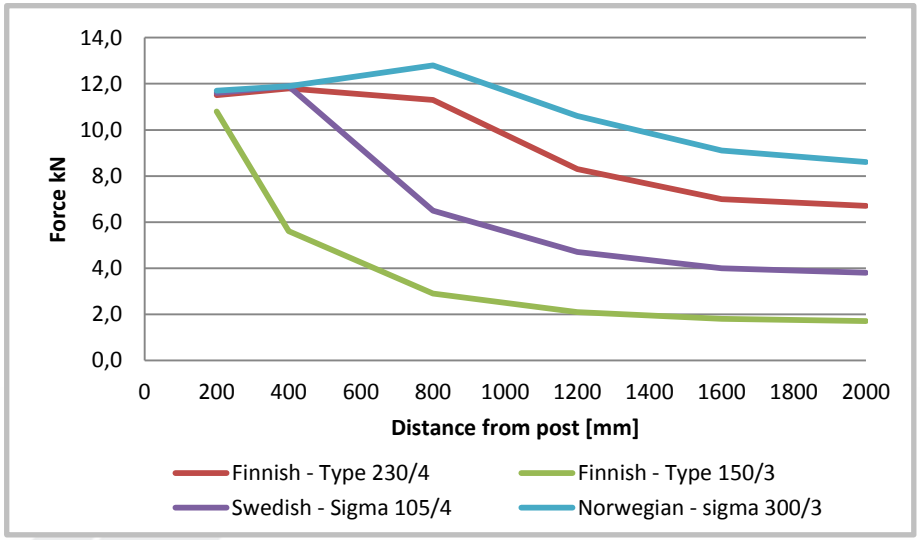
Conclusion:

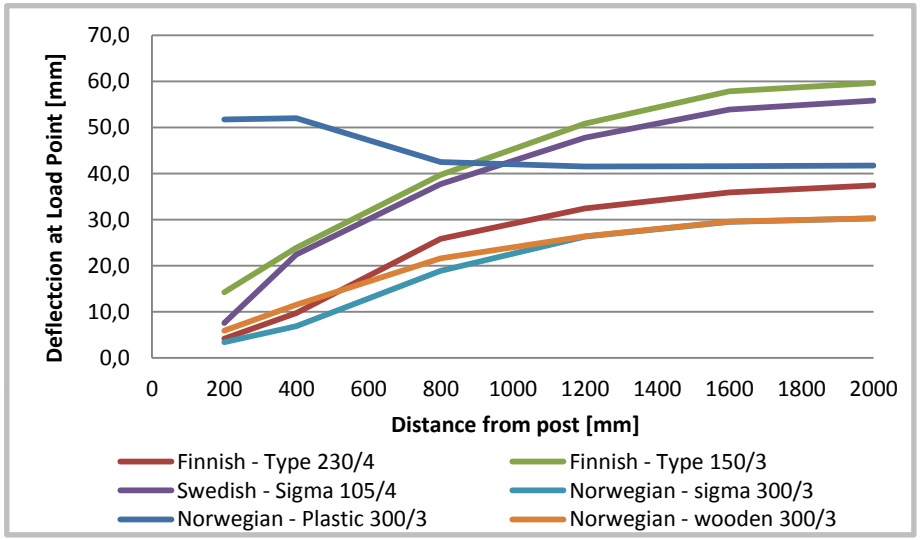
- Safety barriers should be seen as a whole and the evaluation of its component is not generally accurate enough.

Historical background

Impact tests to assess safety barriers performances to snow plough loads

- Quasi-static loading test
  - No-damage capacity curve.





Conclusion:

- The deflection under the plough load is of major importance and more reliable for the classification of safety barriers than the force at failure.

Historical background

Impact tests to assess safety barriers performances to snow plough loads

- Simulation of snow clearing
  - Snowplough truck constantly pressing the rail and sliding.
  - Multiple passages along the safety barrier.

Conclusion:

- Flexible safety barrier could deal better with these loads than a barrier with stiffer posts

Historical background

Impact tests to assess safety barriers performances to snow plough loads

- Field exposure test
  - Test the durability of the selected safety barrier on site.
  - Any deformation, flattening, dent or scrape is reported.

Conclusion:

- New systems can be tested/classified comparing systems deformation on site

Historical background

Studying the subject

- Experimental tests
  - Drop test
  - Quasi-static tests
  - Simulation of snow clearing
  - Exposure tests

- Evaluation methods
  - Control equation
  - Design based
  - Snow bank static load

Historical background

Evaluation methods to assess safety barriers performances to snow plough loads

- Control equation
  - from the offshore field applied to pipes design exposed to possible boat collision.
  - dent and minimum load resistance are estimated

$$P = 150 \cdot f_y \cdot \frac{t^2}{4} \cdot \sqrt{\frac{\delta_d}{d}}$$

P load resistance,
f_{yd} yield strength,
t thickness of the rail,
d theoretical diameter of the rail
δ depth of the dent

Conclusion:

- Any combination of fyd, t and δ resulting in P<15 kN is considered to be too weak for holding loads caused by snow plough clearing operations.

Historical background

Evaluation methods to assess safety barriers performances to snow plough loads

- Geometrical and strength evaluation

Class	Modified material thickness of a rail in steel		Modified section modulus against horizontal loads		Strength against vertical loads of the connection between a post and a rail
	Open profile (mm)	Tube (mm)	Rail (cm^3)	Post (cm^3)	
4	≥ 4	≥ 2.9	≥10	≥12	≥ Shear strength of M10 4.6 bolt
3	≥ 3	≥ 2.2	≥5	≥9	≥ Shear strength of M10 4.6 bolt
2	Rope fence				
1	Other				

"Modified" means that the real thickness and section modulus shall be re-evaluated in order to include variations due to material quality

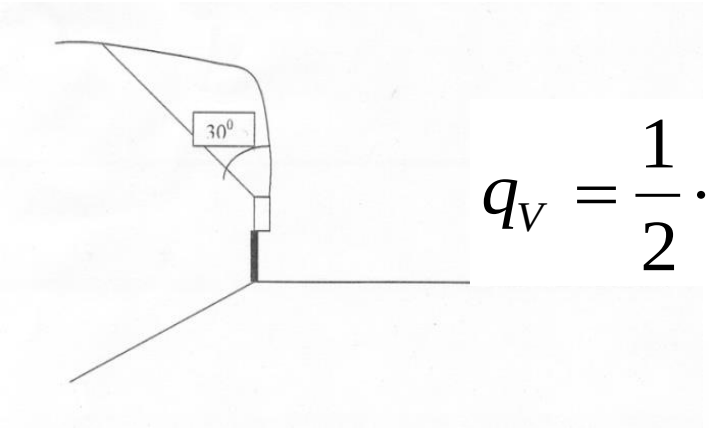
Conclusion:

- Simple evaluation method that allow a design base classification

Historical background

Evaluation methods to assess safety barriers performances to snow plough loads

- Snow bank static load
  - load is represented by the triangle pressing on the safety barrier



$$q_V = \frac{1}{2} \cdot \rho \cdot g \cdot h^2 \cdot \sin(30)$$

q_v load/meter,
ρ snow density (400 kg/m^3)
h the height of snow bank over

Conclusion:

- Simple control method to avoid possible damages and compromising safety barriers functionality and performances

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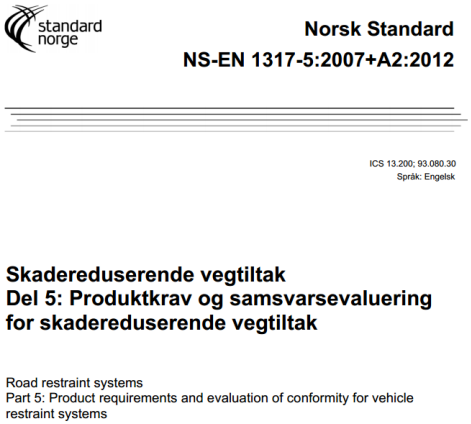

standard norge

Norsk Standard

NS-EN 1317-5:2007+A2:2012

ICS 13.200; 93.080.30
Språk: Engelsk

Skadereduserende vegtiltak
Del 5: Produktkrav og samsvarsevaluering for skadereduserende vegtiltak

Road restraint systems
Part 5: Product requirements and evaluation of conformity for vehicle restraint systems

The resistance to snow removal operations is one of the mandate characteristics of safety barriers

Published standard and future improvements

EN1317 Road restraint systems

- En 1317-5: Product requirements and evaluation of conformity for vehicle restraint systems / Resistance to snow removal:

1. Classification based on “Geometrical and strength evaluation” together with Design prescriptions.

Class	Modified material thickness of a rail in steel		Modified section modulus against horizontal loads		Strength against vertical loads of the connection between a post and a rail
	Open profile (mm)	Tube (mm)	Rail (cm^3)	Post (cm^3)	
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2	Rope fence				
1	Other				

2. Field exposure test together with test guidelines

3. Simulation of snow clearing

Published standard and future improvements

EN1317 Road restraint systems

1. Classification based on “Geometrical and strength evaluation” is:

- based on the experience
- reliable for well-known systems in use in Nordic countries

- of difficult application to new design of safety barriers
- less reliable for safety barriers that have a different design from the ones in use in Nordic countries
- limited to steel safety barriers
- Only two classes (3 and 4) are design based

Published standard and future improvements

EN1317 Road restraint systems

2. Field exposure test is:

- based on real live data/results
- Probably the best way to test a safety barrier

- strongly depending on the type of equipment (snow-plug)
- strongly depending on the skills of the personnel
- depending on the type of barriers chosen for the comparison
- Difficult to repeat
- long-time test

Published standard and future improvements

EN1317 Road restraint systems

3. Simulation of snow clearing is:

- based on real live data/results
- not depending on the type of equipment (snow-plug)
- Repeatable (lab-test)
- short-time test (1day)

- depending on the skills of the personnel
- depending on the type of barriers chosen for the comparison

Published standard and future improvements

EN1317 Road restraint systems

- Resistance to snow removal: future improvements

1.

Classification based on "Geometrical and strength evaluation"

Class	Modified material thickness of a rail in steel		Modified section modulus against horizontal loads		Strength against vertical loads of the connection between a post and a rail
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2	Rope fence				
1	Other				

❖ Include all barriers design
❖ Specify existing category
❖ Add category 0 - not evaluated

2.

Field exposure test

3.

Simulation of snow clearing

❖ Introduce density parameters

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Remarks and conclusions

General

- The damages caused by winter maintenance operations on a safety barriers are depending on many variables

- The assessment to resistance to snow removal within EN 1317-5 is a step forward for improving the correct use of safety barriers

- Having a standard does not mean that the safety barriers currently on the market will be assessed to snow resistance:
  - the producers can declare a “NPD” (no performance declared)
  - this applies only to systems that have been assessed later than August 2012

Remarks and conclusions

The assessment method and the ranking

- The evaluation method described in the standard is based on collected experience and good-practice and therefore limited.
- Calculations or virtual methods have not been able to demonstrate their reliability.
- The ranking can be misunderstood or misinterpreted if not properly explained
- the ranking does not give complete information on safety barriers behaviour when installed on the road

Remarks and conclusions

Improvements

- The evaluation of snow banks weight (vertical loads) should be included
- The standard should move beyond the good-practice method:
  - evaluation method based on the flexibility (elasticity) of the whole system
  - Control equation (offshore field)
- Safety barriers should not be seen as a problem for maintenance operations but as a part of the road system to be maintained operative during winter period
- Ploughing speed is considered a main factor in order to achieve a cost-effective result; An interesting step would be to make different rankings based on equipment's speed class.

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Thanks for your attention!

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