NORGEOSPEC 2002 - A NORDIC SYSTEM FOR SPECIFICATION AND CONTROL OF GEOTEXTILES IN ROADS AND OTHER TRAFICKED AREAS

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Abstract: The Nordic countries Finland, Sweden and Norway established the NorGeoSpec 2002 system in 2002. This is a certification scheme (specification and control) for geotextiles used for separation and filtration in roads. SINTEF Building and Infrastructure is NorGeoSpec-mandated Certification Body.

The system includes five specification profiles based on several characteristics measured with test methods defined by CEN and ISO. Classification of the geotextiles in a specific profile is based on test values and tolerances for the following characteristics: tensile strength, tensile strain, strain energy index, static puncture, dynamic perforation resistance, characteristic opening size and permeability.

The system also includes procedures for field quality control and guidelines for selection of relevant specification profile. The selection of profile is based on subsoil conditions, fill material grain size and combination of construction conditions and quality requirements for the road.

The Norwegian Public Road Administration has implemented the NorGeoSpec-system. They have been using the system in their construction projects for some years, and have collected various experiences with the certification scheme.

This paper will present the NorGeoSpec certification scheme and evaluate the experiences after five years in use.

Keywords: geotextile, separation, filtration, road,

INTRODUCTION

30 years ago a classification system developed in a joint venture project, Alfheim and Sørlie (1977), formed the basis for a common specification system for geotextiles for separation and filtration in roads in Finland, Sweden and Norway. Over the years, the old system was revised resulting in different specification requirements in the three countries, Rathmayer (1993), Schalin (1995). For the same reasons, the systems for quality control also were different in the Nordic countries.

In 1999 the project NorGeoSpec was initiated with the aim to harmonise the requirements and prepare a new common system for specification and control. The project was financed by the Nordic Industrial Funding, the Nordic road authorities and producers and distributors of geotextiles. The work resulted in the new specification system presented in a final project report in December 2002 and in the following years the system was implemented in Finland, Sweden and Norway.

During the years since the introduction of the NorGeoSpec-system, the system has been developed and improved. In 2004 the NorGeoSpec 2002 Report was revised, and Revision 1 is the current version, Watn et al. (2004). The extent of the system has gradually been growing, both the number of producers and the number of certified products.

BASIS FOR THE NORGEOSPEC SYSTEM

The requirements are based on the need for the geotextile after the installation to fulfil its function in the structure for a sufficient service lifetime. The requirements are related to characteristic properties determined by test methods prepared by CEN TC 189 and ISO TC 221. The system is based on experiences with the old systems and results from several research and development projects. Experiences from field and research projects show that the installation and construction phases are important for the performance of the geotextiles, Watn et al. (1998), Rathmayer (2000).

The research has shown a close relation between strain and the mobilised strength for a geotextiles and the tensile stiffness. A stiff geotextile will develop smaller strains but larger tensile stress than a less stiff geotextile, SINTEF report (1996). Research has also verified that there are considerable differences in the susceptibility to damage during the installation and construction between different types of geotextiles, SINTEF report (1997), Watn et al. (1999). Both tensile stiffness and susceptibility to damage during installation were therefore taken into consideration when developing the NorGeoSpec-requirements.

One of the intentions with the NorGeoSpec project was to develop a system for field quality control of geotextiles used for separation and filtration. There is also working going on at European level on field control of geotextiles. In CEN TC 189 it has been requested to identify possible test methods for field quality control purposes.

THE NORGEOSPEC SYSTEM

In the following, a detailed description of the NorGeoSpec-system is given.

Product certification

A quality certificate based on a system corresponding to level 1 will be considered as a sufficient basis for evaluation of compliance with the NorGeoSpec requirements.

A geotextile product has to be verified to comply with the NorGeoSpec requirements based on the data provided by the producer and verified by a Certification Body (CB) to deliver quality certificates for geotextiles and geotextile related products. The verification from the CB shall not be older 2 years. The compliance with the NorGeoSpec requirements can be verified according to two procedures, Quality Certificate (QC) and Independent Product Attestation (IPA).

Quality Certificate (QC):

A product complies with the NorGeoSpec if the values for the 95% tolerance level and the tolerances in the QC certificate comply with the requirements of NorGeoSpec.

Independent Product Attestation (IPA):

The CB can provide a product attestation according to the NorGeoSpec requirements according to the rules given below.

- The producer shall provide average values and tolerances for the characteristics according to Table 1.
- The values corresponding to 95% tolerance level (average value ± the tolerance) shall meet the requirements in Table 2.
- Mean values from accredited tests at an independent laboratory comply with the tolerance limits provided by the producer. The results from the independent laboratory shall not be older than 3 months at the time of the product attestation.

Table 1 Required characteristics, standardised test methods and type of requirement

Required characteristic	**Standardised test method**	**Requirements (nominal value ∓ tolerance)**
Mass per unit area	EN ISO 9864	Maximum tolerance value
Tensile strength Average value MD and CMD	EN ISO 10319	Minimum strength Maximum tolerance value
Static puncture	EN ISO 12236	Maximum tolerance value
Tensile strain at max load Average value MD and CMD	EN ISO 10319	Minimum elongation Maximum tolerance value
Strain Energy Index Average value MD and CMD	EN ISO 10319	Minimum energy index
Dynamic perforation resistance	EN ISO 13433	Maximum hole size Maximum tolerance value
Characteristic opening size, O_{90}	EN ISO 12956	Maximum characteristic opening size Maximum tolerance value
Permeability normal to the plane without load	EN ISO 11058	Minimum permeability Maximum tolerance value

Delivery control

The delivery control is to be performed according to a proposed standard for on-site deliver control (under preparation by TC 189). For products manufactured under attestation of conformity system equal to 1+ only identification tests are necessary. If they fail it is to be decided by the client, whether additional tests for attestation of conformity with this specification are to be made or if the lot is to be rejected. The frequency of the control is related to the amount of geotextile in the delivered lot. The frequency of delivery control shall be at least:

- For products covered by a QC procedure (equivalent to the attestation of conformity level equal to 1+):
  1 every 50 000 m² minimum but 1 test above 10 000 m²
- For products covered by the IPA procedure (equivalent to the attestation of conformity level 2+):
  1 every 10 000 m², but minimum 1 test above 1 000 m²

For products manufactured under attestation of conformity system equal to 2+ the delivery control may be performed according to a Simplified Procedure (SP) or, if required by any of the parties, to an Extended Delivery Control (EDC). If the product is not accepted as complying with the requirements according to the SP any of the parties may require that the delivery control shall be performed according to EDC.

Simplified procedure (SP)

The marking and labelling of the rolls and of the products shall be checked. The marking of the products shall be according to EN ISO 10320. The compliance of characteristics with the values defined by the producer shall be made on measurements made on two representative samples (A and B) taken from different rolls. Sampling shall be made

according to EN ISO 9862. The characteristics to be controlled on sample A in the simplified procedure are mass per unit area and tensile strength or maximum force from CBR-test

The tensile strength can be checked by wide width tensile test according EN ISO 10319 or by a simplified test method using a 50 mm wide strip. The following procedure will be followed:

1. If the test result(s) (average of tested sample) for the particular characteristic is (are) within the tolerance values given by the producer the product is accepted.
2. If the test result(s) (average of tested sample) for the particular characteristic is (are) outside 1.5 times the tolerance values provided by the producer the product does not comply with respect to the characteristics. Any of the parties may then require delivery control according to EDC.
3. If the test result(s) (average of tested sample) for the particular characteristic is (are) within 1 and 1.5 times the tolerance values given by the producer sample B shall be tested. If the test result(s) (average of tested sample) of the sample B for the same particular characteristic is (are) within the tolerance values provided by the producer the product is accepted as complying with respect to that characteristic. If the test results(s) is (are) outside the tolerance values given by the producer the product does not comply with respect to the characteristics. Any of the parties may then require delivery control according to EDC.

Extended Delivery Control (EDC).

The delivery control according to EDC may be performed on request by any of the parties. EDC is to be based on mean values from accredited tests performed at an independent laboratory. The marking and labelling of the rolls and of the products shall be checked. The marking of the products shall be according to EN ISO 10320.

The compliance of characteristics with the values defined by the producer shall be made on measurements made on two represtative samples (A and B) taken from different rolls. Sampling shall be made according to EN ISO 9862.

The characteristics to be controlled on sample A in the EDC procedure are; mass per unit area, tensile strength, tensile strain at maximum load and dynamic perforation resistance.

If the test result(s) (average of tested sample) for the particular characteristic is (are) within the producers tolerance values the product is accepted.

Specification profiles

The system includes five specification profiles based on seven different physical, mechanical and hydraulical characteristics. All requirements are based on characteristics and test methods prepared by CEN TC 189. The required values for the specification profiles are presented in Table 2. The tensile strength and strain values refer to the mean of machine and cross machine direction tested according to ISO 10319. The most significant change compared to previous systems is the definition of the requirement on minimum failure strain and the introduction of an energy requirement. The energy requirement is introduced to allow for a larger span in geotextile properties. Products with lower failure strain can compensate with higher strength to achieve the same failure energy. The requirements allow for a wider range of products to be used than the old systems.

Table 2 Required values corresponding to 95% confidence limits

Characteristic	Maximum tolerance*	Required values† corresponding to 95% confidence limit				
		Specification profiles				
		1	**2**	**3**	**4**	**5**
Min. tensile strength (kN/m), $F_{a,95}$	-10%	6	10	15	20	26
Min. tensile strain at max. load (%), $\varepsilon_{a,95}$	-20%	15	20	25	30	35
Max. cone drop diameter (mm)	+20%	42	36	27	21	12
Min. energy index (kN/m), $R_{a,95}$		1.2	2.1	3.2	4.5	6.5
Min. velocity index‡ (10^{-3} m/s)	-30%	3	3	3	3	3
Max. char. opening size, O_{90}(mm)	∓ 30%	0.2	0.2	0.2	0.15	0.15
Max. tolerance for mass per unit area		∓ 12%	∓ 12%	∓ 10%	∓ 10%	∓ 10%
Max. tolerance for static puncture strength		-10%				

* The tolerance shall be stated by the manufacturer, this table gives the maximum allowable tolerance in the accompanying document to the CE-mark.

† The tolerances are not to be added to the required values. The nominal values + / - the tolerance shall fulfil the requirement.

‡ In the CE marking the velocity index are given. The relation between the permeability (K) and the velocity index (VI_{H50}) are: $VI_{H50} = K * 50/t$, where t is the geotextile thickness in mm. This relation is only valid for permeability test with laminar flow.

Strength and strain properties, 95% confidence limits

The 95% confidence limits for strength and strain properties are calculated as:

$$F_{MD,95} = \{F_{MD} - T_{F,MD}\}, \quad F_{CMD,95} = \{F_{CMD} - T_{F,CMD}\}$$
$$\varepsilon_{MDa,95} = \{\varepsilon_{MD} - T_{\varepsilon,MD}\}, \quad \varepsilon_{CMD,95} = \{\varepsilon_{CMD} - T_{\varepsilon,CMD}\}$$

For the tensile strength and tensile strain at maximum load the specifications are related to average properties in machine and cross machine direction. To give limited credit for large differences in strength MD and CMD direction, a uniformity requirement (U = 1.5) is included in this specification. Strength values higher than 1.5 times the minimum of the MD and the CMD direction is not accounted for. The 95% confidence limits for the average properties are then calculated as:

$$F_{a,95} = 1/2 \cdot \{F_{MD,95} + F_{CMD,95}\}, \quad \lfloor F_{a,95} \le \tfrac{1}{2} \cdot (1+U) \cdot Min(F_{MD,95}, F_{CMD,95}) \rfloor$$
$$\varepsilon_{a,95} = 1/2 \cdot \{\varepsilon_{MD,95} + \varepsilon_{CMD,95}\}$$

Strain energy index, 95% confidence limit

The strain energy index *R* is defined as the product of the maximum tensile strength multiplied with the strain at maximum strength divided by two. The average of MD and CMD direction is used for both strength and strain.

$$R_a = 1/2 \cdot F_a \cdot \varepsilon_a$$

The manufacturers are not obligated to give the tolerance value for the strain energy index R. T_R is therefore estimated on basis of the tolerances for strength and strain. The average tolerance in machine and cross direction is calculated as:

$$T_{F,a} = {}^1/_2 (T_{F,MD} + T_{F,CMD}), \qquad T_{\varepsilon,a} = {}^1/_2 (T_{\varepsilon,,MD} + T_{\varepsilon,CMD})$$

The nominal value for the average strength and strain properties is calculated as:

$$F_a = 1/2 \cdot \{F_{MD} + F_{CMD}\}, \quad F_a \le \tfrac{1}{2} \cdot (1+U) \cdot Min(F_{MD}, F_{CMD})$$
$$\varepsilon_a = 1/2 \cdot \{\varepsilon_{MD} + \varepsilon_{CMD}\}$$

Assuming that the tensile strength and the strain at maximum strength are independent variables, the tolerance of the strain energy index can then be estimated with the following formula:

$$T_{R,a} = \tfrac{1}{2} \sqrt{T_{F,a}^2 \cdot \varepsilon_a^2 + F_a^2 \cdot T_{\varepsilon,a}^2}$$

Note! The calculation must be done with the tolerances in engineering units.

The 95% confidence limit for R is then found as:

$$R_{a,95} = 1/2 \cdot F_a \cdot \varepsilon_a - T_{R,a}$$

GUIDELINES FOR SELECTION OF SPECIFICATION PROFILE

The selection of specification profile may be based on subsoil conditions, fill material grain size and a combination of construction conditions and quality requirement for the road. For conditions not covered by these guidelines, a special evaluation required specification profile should be done.

Subsoil

The subsoil is divided into two groups, *soft* and *firm*. Evaluation of type of subsoil can be done according to the remarks.

- Soft - soft clay with undrained shear strength ≤ 25 kPa, and peat
- Firm - medium and stiff clay with undrained shear strength > 25 kPa, and sand and gravel

Construction conditions

The construction conditions are divided into two groups, *normal* and *favourable*. Evaluation of type of construction conditions can be done according to the remarks.

- Normal - two or more of the following conditions: Heavy construction traffic, angular and sharp fill material, compaction with heavy and vibrating equipment, construction traffic on fill layers with thickness less than 300 mm.
- Favourable - for fill material with maximum stone size < 200 mm and layer thickness >1,5 x max. stone size.

Traffic

The traffic is divided into two groups, *high* and *normal*. Evaluation of type of traffic can be done according to the remarks.

- High - medium and high volume roads (>500 vehicles per day)
- Normal - access roads, small roads (<500 vehicles per day)

Based on these input parameters the selection of relevant specification profile can be done according to Table 3.

Table 3. Selection of relevant specification profile.

Sub soil	**Construction conditions**	**Traffic**	**Maximum grain size (d_{max}) in fill material (mm)**			
			$d_{max} < 60$	$60 < d_{max} < 200$	$200 < d_{max} < 500$	$d_{max} > 500$
Soft	Normal	High	3	4	5	5
		Normal	3	4	4	5
	Favourable	High	3	3	4	5
		Normal	2	3	4	4
Firm	Normal	High	2	3	3	4
		Normal	2	2	3	3
	Favourable	High	2	2	3	3
		Normal	2*	2	2	3

* Specification profile 1 may be used for roads with temporary traffic, access roads or similar.

EXPERIENCES SINCE THE BEGINNING IN 2003

During the years since the introduction of the NorGeoSpec-system, the system has been developed and improved. The extent of the system has gradually been growing, both the number of producers and the number of certified products. In the following the development and experiences with some main aspects are described.

Development in extent

The system has from its beginning seen a growing extent as illustrated in Figure 1and Figure 2. The figures show a continuous growth in volume both for producers (Figure 1) and certified products (Figure 2) during the years since the NorGeoSpec-system was established. The 2008-coloum shows the status of today (March 2008). Still more new products are in process for certification and the number of certified products is expected to increase further during 2008.

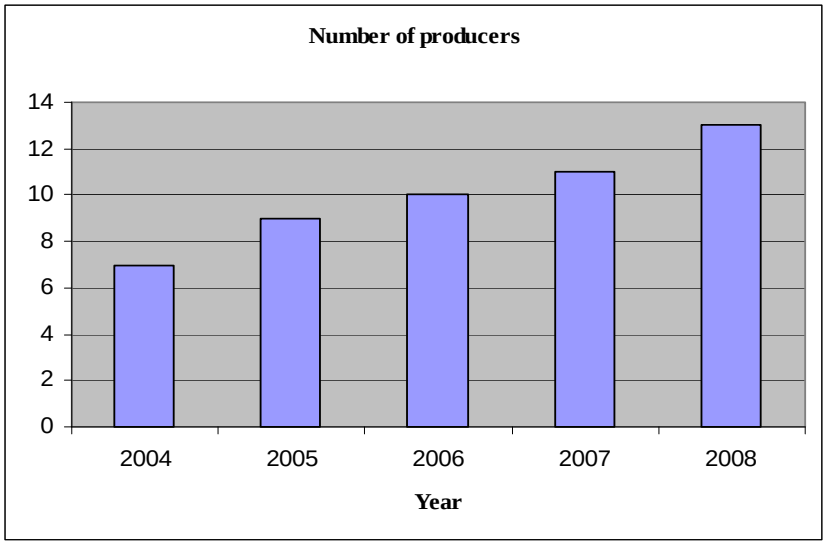

Figure 1. Number of producers within the NorGeoSpec-system.

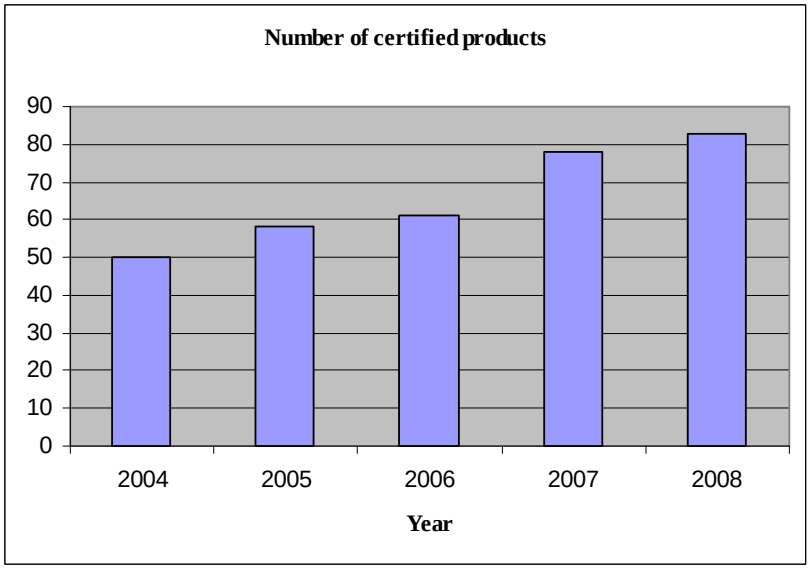

Figure 2. Number of NorGeoSpec-certified products.

Distribution on specification profile

As described, the system includes five specification profiles, ranging from Profile 1 which is the slightest quality, to Profile 5 which is the heaviest quality. As shown in Figure 1, 13 producers have geotextile products certified in the NorGeoSpec-system today. 9 of them offer products in all five specification profiles, whilst 3 of them offer products in 3 or 4 different profiles. The number of certified products is 82 at the moment (March 2008) and Figure 3 shows that these 82 products are quite evenly distributed between the different profiles. All specification profiles are covered with a large number of certified products, also profile 1 and 5 where smaller sales volumes are likely. Especially the large number of products certified in Profile 1 is noticeable since NorGeoSpec only recommend Profile 1 in special cases as temporary roads, access roads or similar, see Table 3.

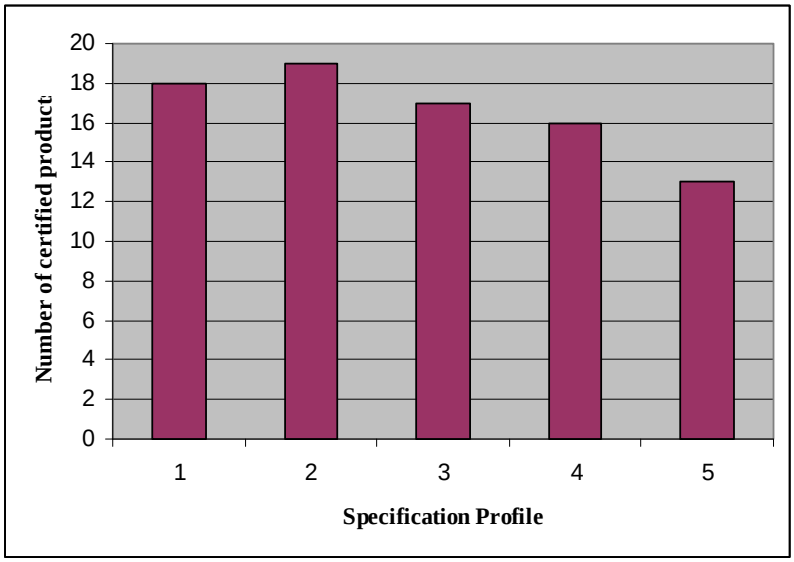

Figure 3. Number of products certified in the different specification profiles.

Web-site

As an element of making the NorGeoSpec-system known and make information more easily available, the web-site www.norgeospec.org was established in December 2003. The web-site is simple, but gives information about the establishing of the NorGeoSpec-system, the participants and background. The two possible procedures, QC and IPA, for verifying the compliance with the NorGeoSpec-requirements are also described.

A hyperlink on the web-site gives access to the latest version of the NorGeoSpec Report "NorGeoSpec 2002. A Nordic system for specification and control of geotextiles in roads san other trafficked areas". The report can be downloaded and if desired, printed out.

A useful service on the web-site is the *application profile test*. The test is developed for manufacturers and distributors planning to introduce their products to the Nordic marked. By entering the properties of their products into an online test page, the applicants can evaluate the application profile of their geotextile on their own.

The web-site is continuously updated as new products are certified, existing certificates are renewed and old certificates expire. A hyperlink gives access to an updated overview over geotextiles with NorGeoSpec 2002 certificates. All certified products are listed and also the name of the manufacturer, expiring date, specification profile and certification procedure.

The latest improvement of the web-site is access to the complete certificate for all products. A hyperlink gives access to the complete certificate for each certified product. The certificates have been public documents all the time, but by publishing on the web-site, the availability has been much better.

QC versus IPA

Compliance with the requirements can be achieved by two different procedures, Quality Certificate, QC or Independent Product Attestation, IPA as described earlier. The experiences have show that the QC dominated from the very beginning and is today the sole procedure.

From the beginning the most manufacturers chose QC, only two chose the IPA-procedure. In 2004 these two producers had a total of 7 products certified with IPA. In 2005 the volume was reduced to one producer with 3 products and since 2006 no certified products have had IPA. Today all products are certified according the QC-procedure.

Implementation and experiences within the Road Authorities

The Norwegian, Swedish and Finish Road Authorities have implemented the NorGeoSpec-system in different ways. In Norway the road construction design and materials specifications (Handbook 018) from the public road authorities (Norwegian Public Roads Administration, NPRA), regarding geotextiles, refers to the NorGeoSpec system as far as classification and certification is considered. The choice of use class (specification profile) for the various applications differs somewhat from the recommendations in the NorGeoSpec report. As for an overview of relevant geotextile products for separation applications, the Handbook 018 refers to the NorGeoSpec-web site.

The general impression is that the system is known among the consultants and is referred to in the design specifications. However, there are room for improvement. The knowledge of NorGeoSpec among consultants in Norway is supposed to be medium or low, in spite of the obvious NorGeoSpec reference in the Handbook 018. There are probably some consultants who still refer to the old classification routines. From time to time this type of outdated references is seen in new project descriptions (tender documents etc).

The road authorities in Norway have, to some extent, established a system for taking random samples of geotextiles on site, and testing them in their own facilities. The testing includes products identification, weight per area

unit, tensile strength and corresponding elongation, and drop cone penetration. The testing is carried out according to the NPRA's guidelines, which in this respect is based on CEN standards.

During the period 2005-2007 about 50 samples were tested by the Norwegian road authorities. About 25 % of these did not meet the NorGeoSpec-requirements for tensile strength, elongation, energy index or unit weight. For 7 samples, the unit weight was below the declared value minus tolerance. This indicates that the manufacturers pay little attention to this property, and may also be the reason for other properties failing to meet the requirements. 7 samples did not meet the values in the NorGeoSpec-certificate or manufacturer's documentation, but were still within the NorGeoSpec specification profiles.

In the certificates or manufacturer's documentation it is often stated different properties in MD and CMD direction. For some of the samples the MD and CMD values were outside of tolerance, but with an average value within specification profile.

It is observed that for some of the samples, the unit weight and tensile strength (and elongation) has a lot of variation for the 10 sub-samples (tested pieces). The Norwegian road authorities suggest that it should be considered to establish a requirement on the maximum allowable standard deviation for the 10 sub-samples.

SUMMARY

A common Nordic certification system for geotextiles used in roads was established in 2003. The system is described in the report "NorGeoSpec 2002. A Nordic system for specification and control of geotextiles in roads and other trafficked areas".

The system has been implemented by the road authorities in the three Nordic countries Sweden, Finland and Norway. During the years since the introduction, the system has been developed and improved. The extent of the system has gradually been growing, both in number of producers and in number of certified products.

The experiences, especially from the Norwegian road authorities, shows that there are still room for improvement, especially when it comes to compliance with the certified values.

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