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## Administrative report: TC8 - Frost

### Compte rendu sur la CT-8

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#### 1 INTRODUCTORY INFORMATION

The name of the committee was the Technical Committee on Frost in Geotechnical Engineering, TC No. 8, Frost.

TC8 was hosted during the period by The Finnish National Society. The Chairman of the Committee was Dr. Seppo Saarelainen (Finland) and secretary Mr. Henry Gustavsson (Finland.). The core members of the Committee were:

Dr. Karen Henry (USA)  
 Dr. Arne Instanes (Norway)  
 Prof. Sven Knutsson (Sweden)  
 Prof. Jean-Marie Konrad (Canada)  
 Prof. Takashi Ono (Japan)

The ordinary members were:

Dr. A-L. Berggren (Norway)  
 Dr. T. Boromisza (Hungary)  
 Prof. G. Franck (France)  
 Dr. V.I. Grebenets (Russia)  
 Mr. W.T. (Bill) Horne, P.Eng. (Canada)  
 Dr. T. Ishizaki (Japan)  
 Mr. P. Lerat (France)  
 Dr. V.V. Shamov (Kazakhstan)  
 Prof. K. Skarzynska (Poland)  
 Prof. J-F Thimus (Belgium)  
 Prof. J.I.G. Vardoulakis (Greece)

Terms of reference:

- Permanent deformations in thawing subgrades under traffic loading
- Indirect methods to estimate frost heave characteristics
- Performance of insulation materials, by-products and waste materials in relation to frost action
- Pavement surface; thermal properties and temperatures
- To co-operate with the working group on "Permafrost Engineering" of the International Permafrost Association (IPA)
- To arrange the next International Symposium on Ground Freezing and Frost Action in Soils, together with the International Symposium on Ground Freezing (ISGF).

#### 2 EXECUTIVE SUMMARY

Technical Committee on Frost, TC8, was established first in 1985. During the first working periods the committee prepared recommendations for "Reference frost susceptibility criteria" and for "Definitions, terminology and symbols pertaining to seasonal frost". Later recommendations e.g. for determining the elastic stiffness moduli of thawing subgrades and a procedure of a reference frost heave test including sam-

pling have been produced. Also co-operation within the last years has been promoted with IPA and ISGF in terms of arranging joint symposiums with both organizations.

In the 5<sup>th</sup> period 2001-2005 the unfinished work items of earlier periods have been continued as well as new tasks have been carried out. One of the main objectives of the committee is to improve understanding on freeze-thaw problems and their solutions in an economically reasonable manner. Most important specific tasks are listed in the Terms of reference. To achieve these objectives, members of TC8 have co-operated in ways of correspondence and annual meetings. Meetings of TC8 have been arranged during international conferences and symposiums: 2001 in Istanbul, 2003 in Zurich, and 2004 in Edmonton. Descriptions and reports presenting the achievements and results of the work done are presented in more detail in the next chapter and in appendices.

#### 3 MAIN REPORT

Here are presented reports on each of the Terms of References of TC8 in period 2001-2005. More detailed reports can be found from the Appendices.

##### 3.1 *Permanent deformations in thawing subgrades under traffic loading*

- Saarelainen S., *Thaw penetration, thaw weakening and permanent deformations on pavements* (Appendix 1): Aspects on evaluation of pavement deformations due to and during thaw weakening are described and discussed. At first, thaw penetration is estimated according to the local surface temperature conditions. The development of pavement surface modulus is estimated considering the lowered stiffness of thawed pavement layers as well as the thickness and modulus of thawed subgrade. Permanent deformations in the thawed subgrade, causing rutting can be then estimated applying a subgrade rutting model.

##### 3.2 *Methods to estimate frost heave characteristics*

- Slunga E., Saarelainen, S., *Determination of frost-susceptibility of soils* (Appendix 2): Determination of frost-susceptibility of soils is delt and given proposals for recommended methods and procedures. This presentation is a short summary of the earlier work of TC8.
- Konrad J-M., *Indirect estimation of segregation potential based on soil index properties* (Appendix 3): A new approach to estimate segregation potential values using the frost heave response of two reference soils is presented.

The reference characteristics consist of a relationship between segregation potential at zero overburden pressure, specific surface area and average grain size of the fines fraction for two artificial soil mixtures in which the clay mineral is poorly crystallized kaolinite. The prediction of segregation potential values using the reference frost heave characteristics approach is more robust and reliable than other empirical approaches, which do not specifically distinguish between clay and nonclay fines.

- The recommended procedure of a reference frost heave test has been discussed in TC8 for many years. *A Method Description of Frost Heave Test and Thaw Compression Test* (TPPT-R07-1999) that is used e.g. in Finland and is translated by Saarelainen, can be found in internet at TC8's homepages.
- Standardized test methods for frost heave prediction and frost susceptibility of soils are also introduced in Japan. These test methods are established in 2003 by the Japanese Geotechnical Society. Two standards are set up, which are *Test Method for Frost Heave Prediction of Soils* (JGS 0171-2003) and the *Test Method for Frost Susceptibility of Soils* (JGS 0172-2003). The purpose of the frost heave prediction test is to obtain the frost heave ratio, thaw settlement ratio, and other parameters to be used mainly for the frost heave prediction in artificial ground freezing engineering. The purpose of frost susceptibility test is to determine the frost susceptibility of soil in order to obtain the frost heave rate as a representative index for natural soils or replacement materials. Freezing test is carried out one-dimensionally with water intake using saturated specimen. Frost heave ratio of soil is decided by means of carrying out a series of freezing tests with different applied stress and/or freezing rate. Frost susceptibility of soil is determined according to the value of frost heave rate of the specimen obtained under constant freezing rate and applied stress.
- A Swiss Standard published by the Association of Swiss road and traffic engineers presents "*Frost heave test and CBR test after thawing*", which is used Switzerland (SN 670 321. 2004).

### 3.3 *Performance of insulation materials, by-products and waste materials in relation to frost action*

- Saarelainen S., *Recommended design thermal and mechanical properties for frost insulation materials in Finland* (appendix 4): The recommended design values of thermal conductivity and mechanical properties are presented for most common frost insulation products applied, for instance in Finland. The thermal conductivity is a product characteristic affected by moistening. The design value should always be determined as frozen. The earth structure should be so designed that the mechanical strength of the product is high enough compared to the induced stresses, and that the permanent deformations are admissible.

### 3.4 *Pavement surface; thermal properties and temperatures*

- Gustavsson H., *Effect of thermal properties on pavement surface temperatures* (appendix 5): Collected experiences on temperature variation of surface temperatures of different types of pavements for estimation of slippery conditions have been studied. Also methods for modelling of surface temperatures as well as results of modeling and comparisons to measured values are explained. Main focus is given to the effect of an insulation layer on pavement surface temperatures and friction characteristics.

- Saarelainen, S., *Thaw penetration, thaw weakening and permanent deformations on pavements* (Appendix 1). Collected experience on differences of air temperatures and surface temperatures of pavements during thaw are reported in order to be able to predict the period of thaw weakening season.

### 3.5 *To co-operate with the working group on "Permafrost Engineering" of the International Permafrost Association (IPA)*

- TC8 has co-operated with IPA by participating in conferences and in the work IPA's working group on "Permafrost Engineering" in:
  - Workshop on Permafrost Engineering, Svalbard, June 2000
  - International Conference on Permafrost, Zurich, Switzerland 2003

### 3.6 *To arrange the next International Symposium on Ground Freezing and Frost Action in Soils, together with the International Symposium on Ground Freezing (ISGF)*

The next Symposium on Ground Freezing and Frost Action in Soils will be organised in connection to the Cold Regions Engineering and Construction Conference, together with ASCE, in Bangor, Maine, in July 24-26 2006.

## 4 CONCLUSIONS

The importance of frost in the geotechnical engineering of cold regions, both with seasonal frost and permafrost has been re-cognised. Anyhow, there is a continuous need of development in various disciplines of civil, environmental and geotechnical engineering to improve understanding on freeze-thaw problems and their solutions in an economically reasonable manner. Also there is a need for dissemination of the knowledge within the community. The anticipated climate change with its consequences needs serious consideration concerning the safety and risks on the current civil engineering structures as well as the need of reforming the current design rules. These can be best treated and discussed in the forthcoming conferences and meetings.

## 5 SUGGESTIONS FOR FURTHER WORK AND DEVELOPMENTS FOR TECHNICAL COMMITTEE NO 8 ON FROST

The possible, actual topics for the future work of TC8 might include:

- developments on the consideration of frost effects in the design standards, including reference testing
- continuing the work on freeze-thaw on pavements in terms of thermal and mechanical processes
- determination of permanent deformations in thawing pavements
- surface temperatures during freezing and thawing
- influence of freeze-thaw on the permeability of mineral liner materials
- change of design values of freezing and thawing indices due to climate change.
- cooperation with the Ground Freezing community and International Permafrost Association

The continuation of the activity of TC8 on Frost within the ISSMGE is strongly recommended.

## REFERENCES

- JGS0171 - 2003. Test Method For Frost Heave Prediction of Soils. Japanese Geotechnical Society.
- JGS0172 – 2003. Test Method for Frost Susceptibility of Soils. Japanese Geotechnical Society.
- SN 670 321. 2004. Frost heave test and CBR test after thawing ( $CBR_F$ ). Swiss Standard. Association of Swiss road and traffic engineers (VSS). Zurich, 38p.
- TPPT-R07 - 1999. A Method Description of Frost heave test and Thaw compression test, translated by S. Saarelainen. <http://www.hut.fi/Yksikot/Osastot/R/Pohja/TC8/>.

## APPENDICES

- (Full texts are included in the CD publication of this report)
- Saarelainen S., Thaw penetration, thaw weakening and permanent deformations on pavements (appendix 1)
- Slunga E., Saarelainen, S., Determination of frost-susceptibility of soils (appendix 2)
- Konrad J-M., Indirect estimation of segregation potential based on soil index properties (appendix 3)
- Saarelainen S., Recommended design thermal and mechanical properties for frost insulation materials in Finland (appendix 4)
- Gustavsson H., Effect of thermal properties on pavement surface temperatures (appendix 5).