Deformation Properties of Unbound Materials

By

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Outline

- Introduction
- Triaxial testing
- Presentation of some results from my thesis
- Conclusions
- Practical consequences of the results

Introduction

- Unbound granular aggregates are extensively used in pavement structures
- The number of heavy vehicles are increasing and the climate is changing
- The knowledge of the deformation properties of unbound aggregates are still quite limited
- Both the resilient properties (stiffness) and the resistance against permanent deformations are affected by many factors

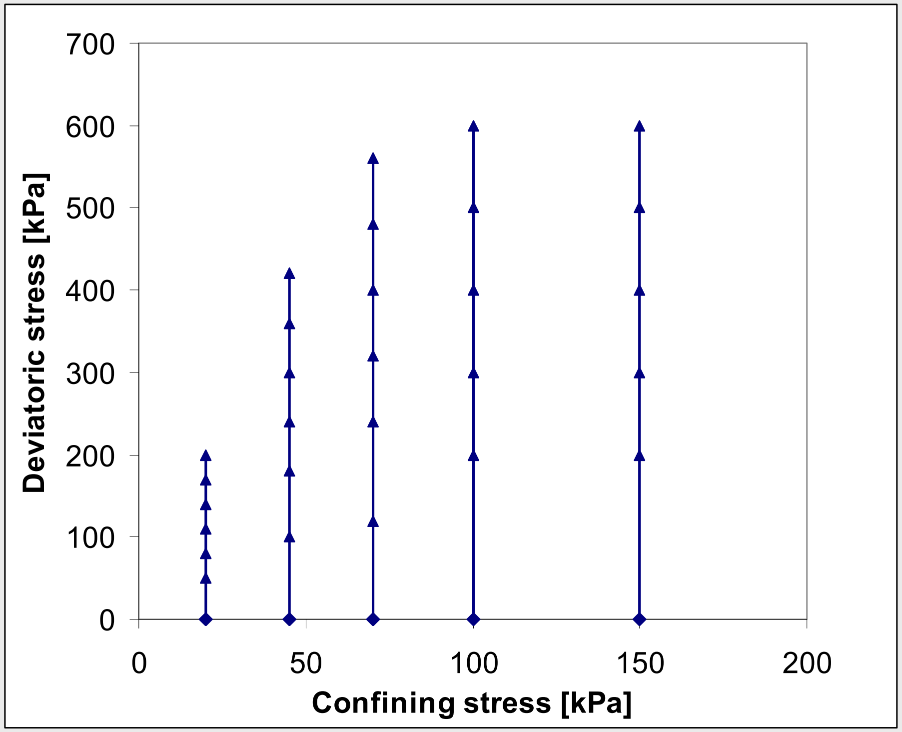
Triaxial testing

- Cylindrical sample covered with a latex membrane
- Simulates the repeated loading of moving traffic (sinusoidal)
- Measures both axial and radial deformation
  - LVDTs (Linear Variable Differential Transformer) measures displacement

(Dongmo-Engeland, 2005)

Loading procedure

- EN 13286-7 Multi stage loading procedure (CEN, 2000), High stress level

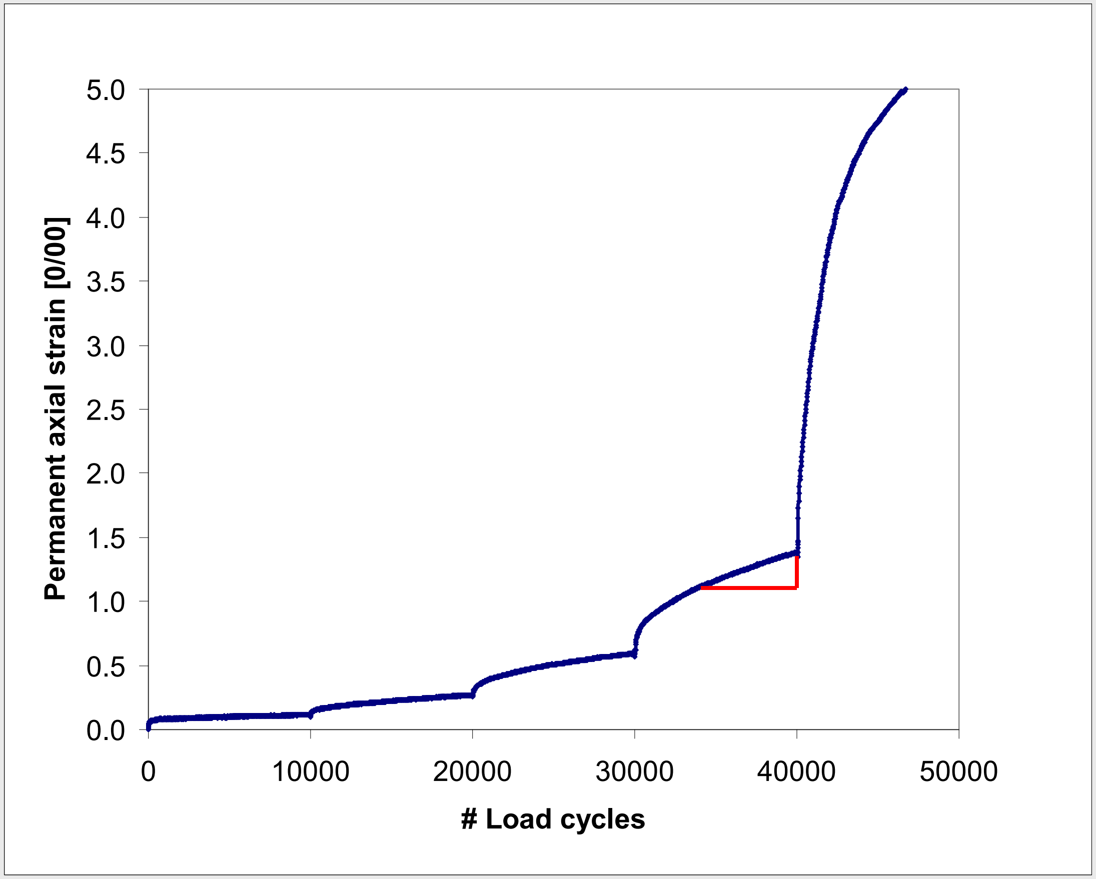


- 5 sequences of confining stress
- Stepwise increasing deviatoric stress
- Frequency: 10 Hz
- 10 000 cycles per load step
- Sinusiodal loading
- Loading interrupted at 0.5 % for each load step

Resilient properties of unbound granular aggregates

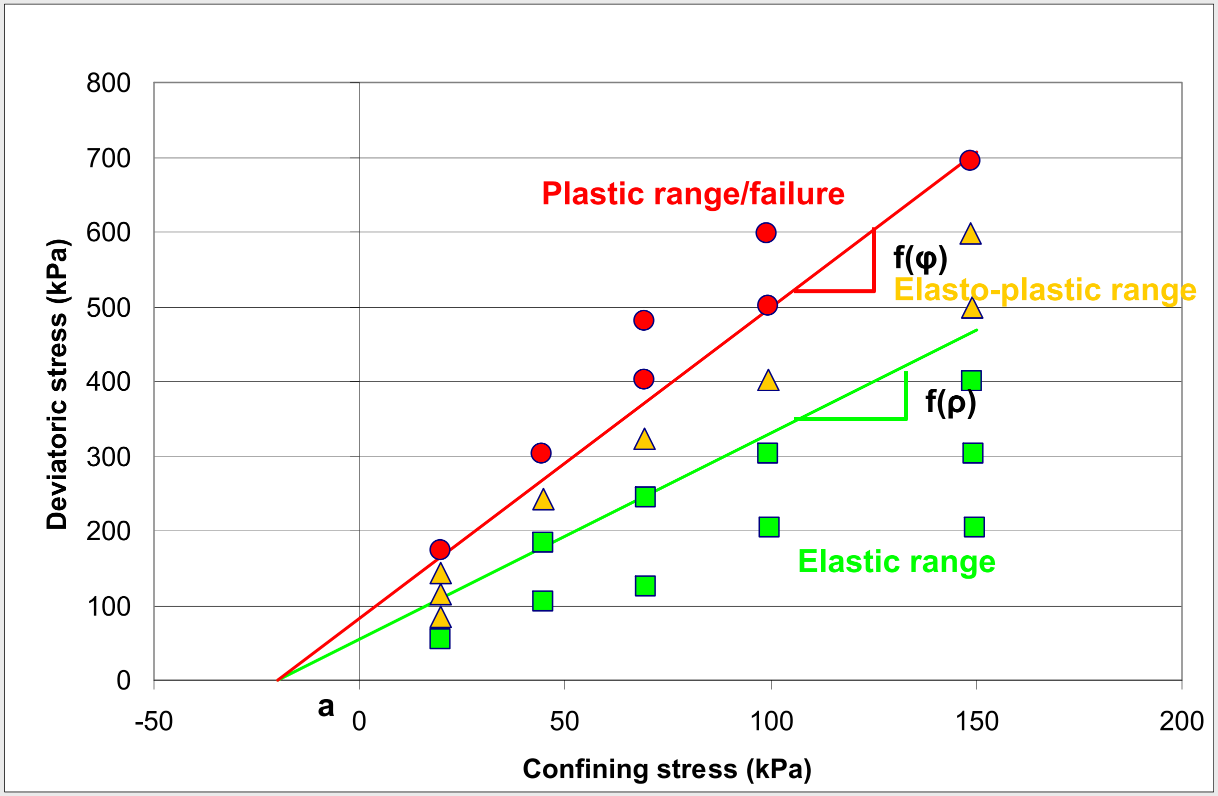
- Resilient properties:
  - May be described by the resilient modulus - M_R and Poissons ratio ν
  - M_R is defined as:
    - $M_R = \sigma_d^{dyn} / \varepsilon_a^e$
  - Poissons ratio is defined as:
    - $\nu = - \varepsilon_r^e / \varepsilon_a^e$
- In this presentation the resilient modulus is plotted as a function of the mean stress

Interpretation regarding permanent deformations



Permanent axial strain as a function of the number of load cycles for one load sequence

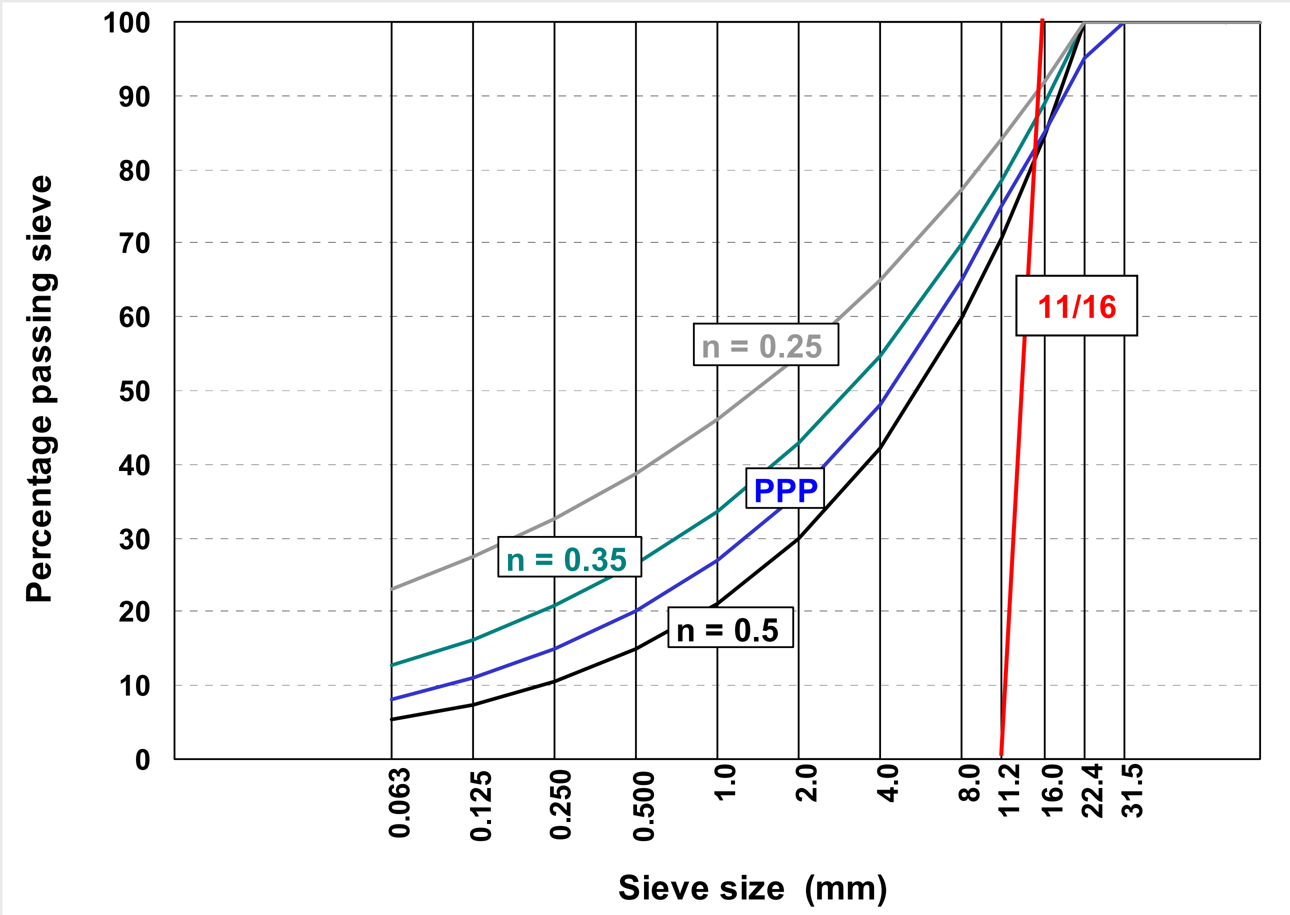
Interpretation regarding permanent deformations



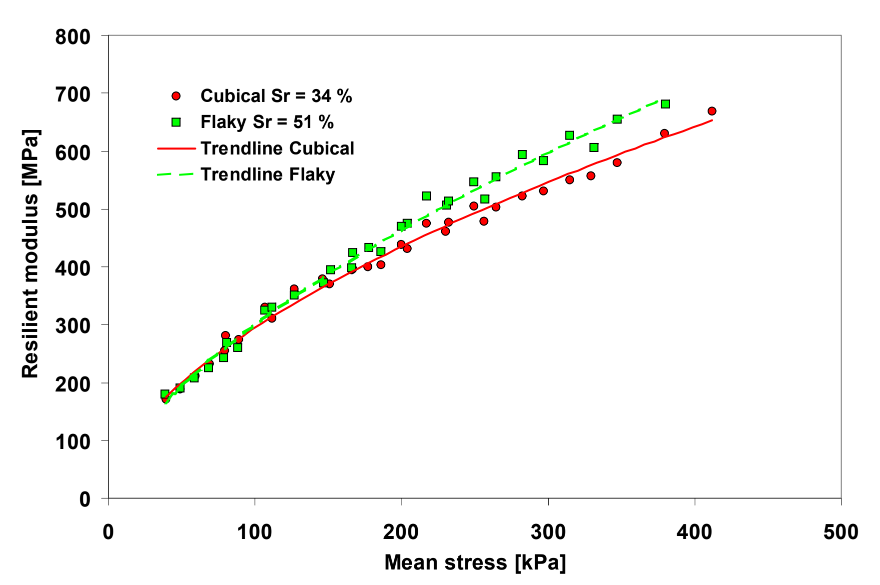
Materials

- Three materials were used througout the study
- Askøy cubical gneiss (LA=17, FI=12)
  - Main minerals are quartz and feldspar
  - Refined through the crushing process
- Askøy flaky gneiss (LA=20, FI=28)
  - Main minerals are quartz and feldspar, but also some mica
  - Taken from an early step in the crushing process
- Swedish mica rich gneiss (LA=24, FI=24)
  - Main minerals are feldspar, mica (33 %)

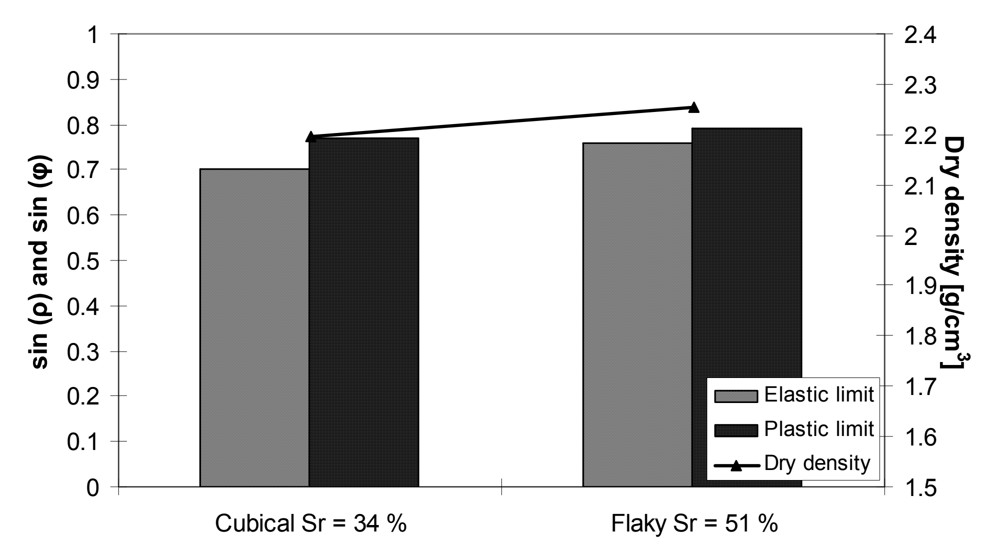
Grain size distributions



Grain shape and surface texture

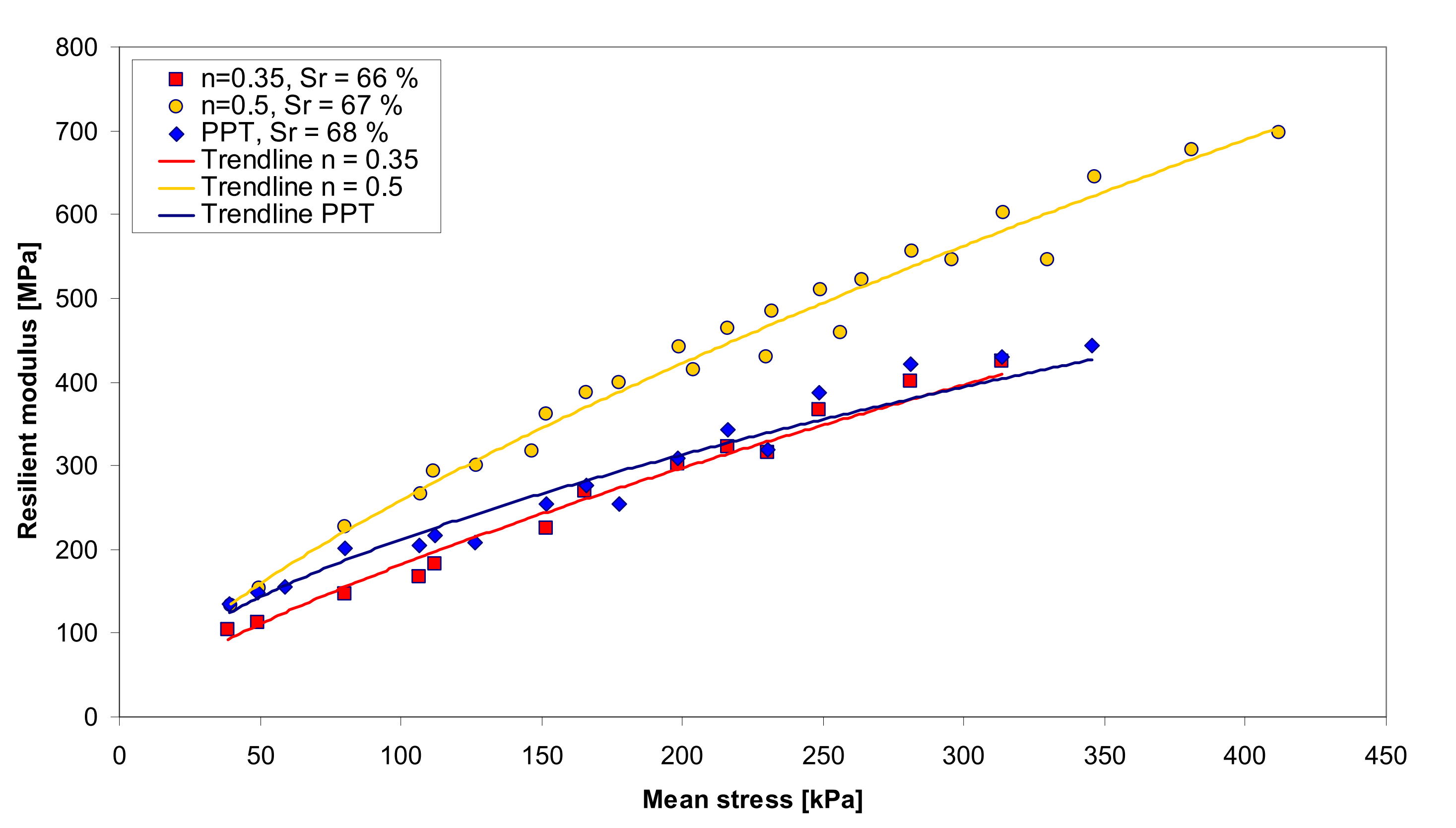


Resilient modulus as a function of mean stress for two materials from Askøy, n=0.35, with comparable degrees of saturation



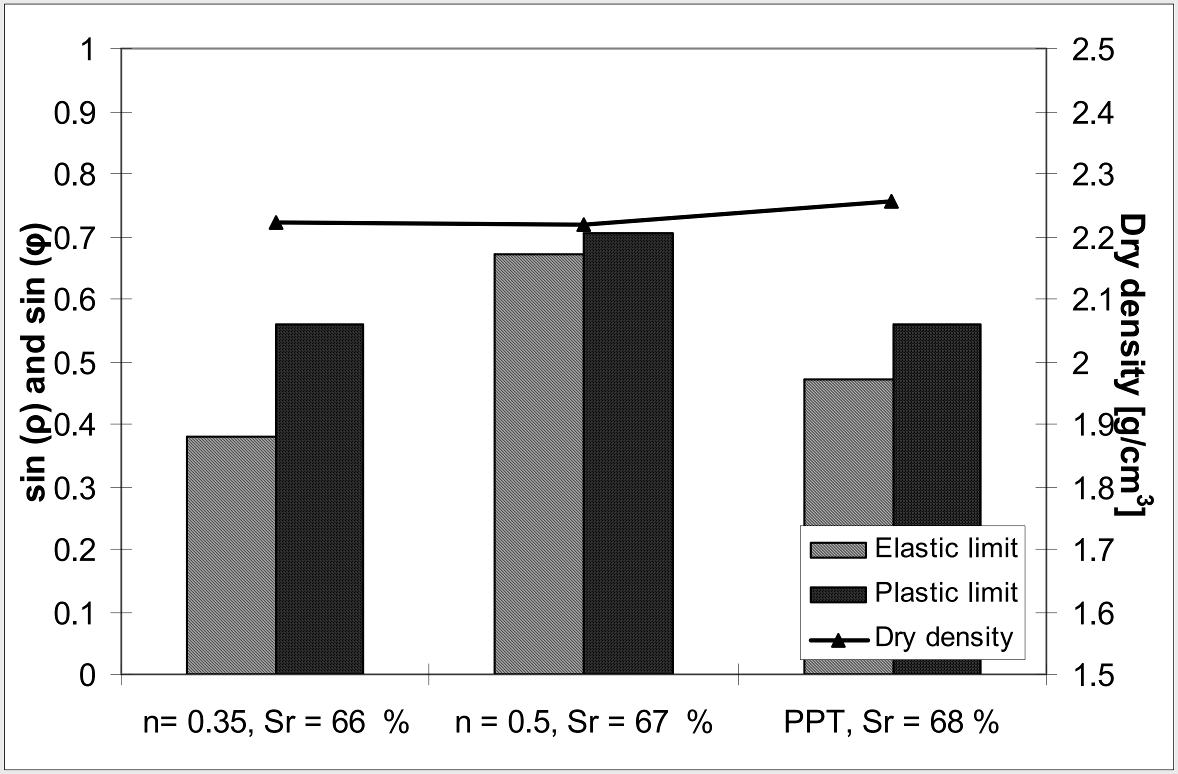
Elastic and plastic/"failure" limit for two materials from Askøy, n=0.35, with comparable degrees of saturation

Grading and fines



Resilient modulus as a function of mean stress three gradings with near the same degree of saturation

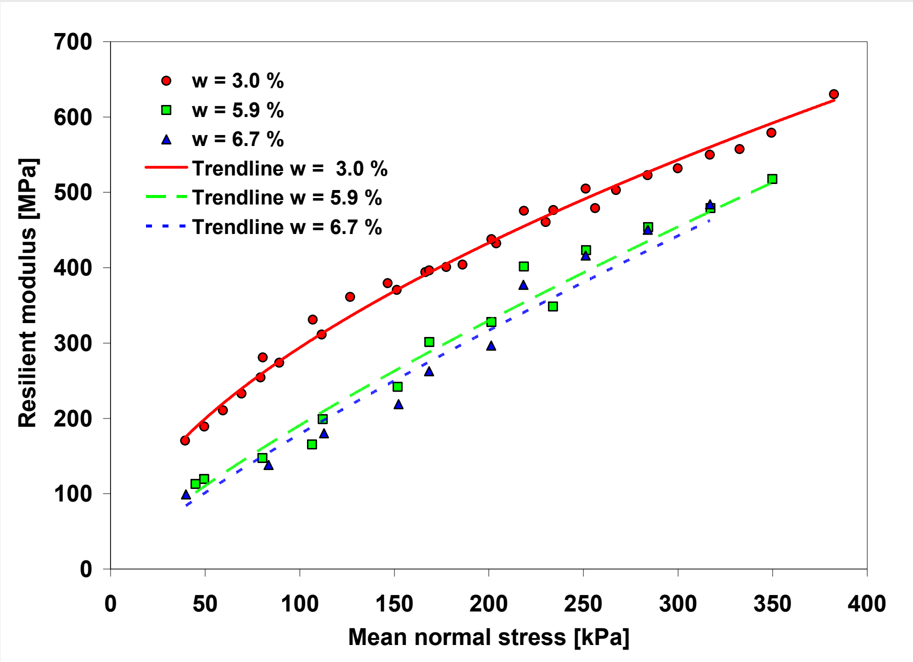
Grading and fines



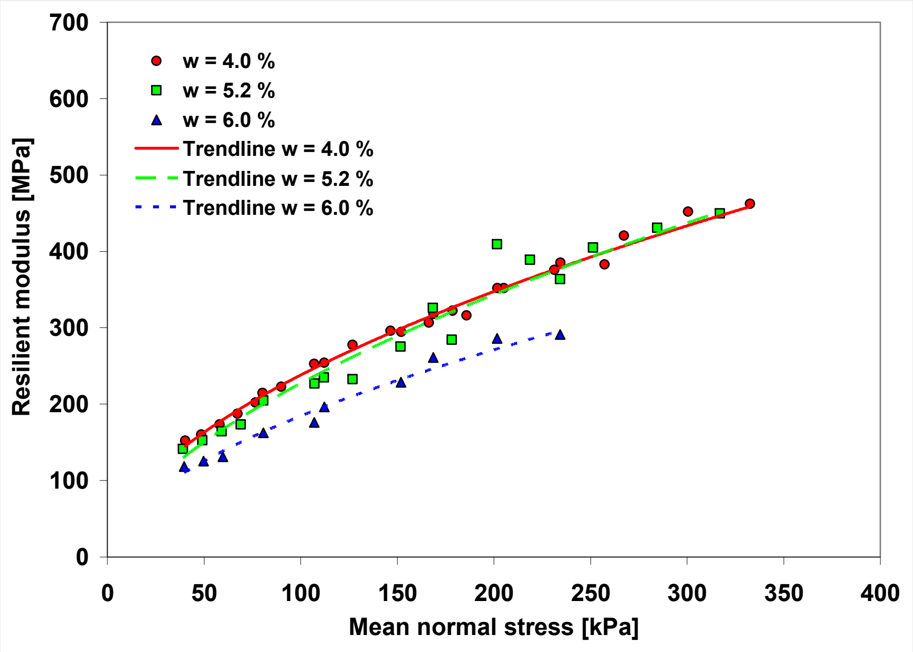
Elastic and plastic ("Failure") limits for three gradings
with near the same degree of saturation (Paper V)

Mineralogy and aggregate type

KOLO VEIDEKKE



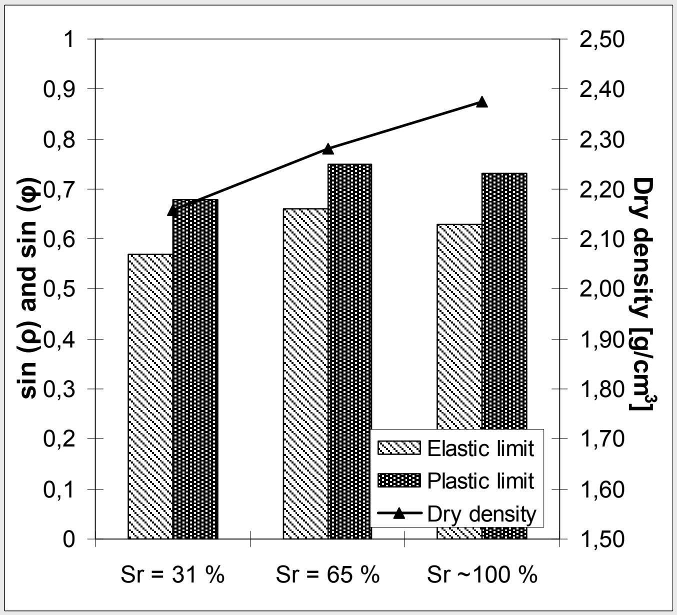
Resilient Modulus as a function of mean stress for Cubical gneiss from Askøy, 0/22 mm, n=0.35



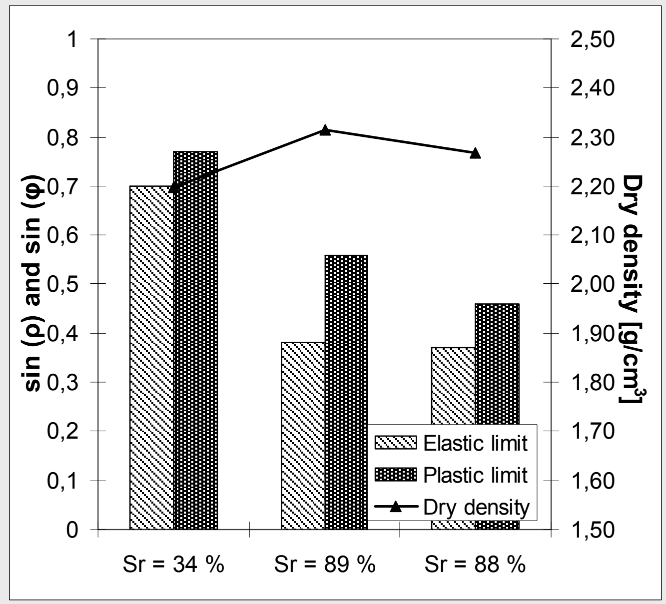
Resilient Modulus as a function of mean stress for Swedish gneiss , 0/22 mm, n=0.35

Moisture

- Single-sized coarse materials – water drains out
- Well-graded materials – sensitivity to water increases with increasing fines content



Elastic and plastic ("Failure") limits for Askøy cubical, 0/22 mm, n= 0.5



Elastic and plastic ("Failure") limits for Askøy cubical, 0/22 mm, n= 0.35

Main conclusions (1)

Grain shape and surface texture

- It is difficult to isolate the effect of grain shape alone, as the dry density and mechanical strength may override the effect
- Rounded materials are more compactable than angular materials, but also more susceptible to permanent deformations
- The effect of material grading interacts with the effect of grain shape, as well-graded materials are less sensitive to changes in the grain shape

Main conclusions (2)

Grading and fines

- Well-graded materials with high fines content are more sensitive to changes in water content
- Not only the content of fines is important, but also the properties of the fines, like the specific surface area, mineralogy and grading
- Single-sized materials may have almost the same deformation properties as well-graded materials, dependent on the mechanical strength

Main conclusions (3)

Moisture

- In well-graded materials the sensitivity to water increases with increasing fines content
- The content of certain minerals in the fines, such as mica, affects the sensitivity to water
- Water does not affect the deformation properties of single-sized materials significantly

Main conclusions (4)

Dry density

- Dry density is affected by parameters like grain shape, grain size distribution, fines content and compaction method
- The deformation properties of a well-graded material are mainly influenced by the dry density up to a certain amount of fines
- Dry density is one of the key parameters for the deformation behaviour, as both the resilient modulus and the resistance to permanent deformations increases with increasing dry density

Practical consequences of the thesis

- The mineralogy of the fines should be taken into account in criterias regarding frost and water susceptibility
- New methods for compaction control in situ is recommended to assure high dry densities
- Design methods based on information from triaxial testing should be developed, especially on the permanent deformation behaviour


Thank you for the attention!