

# **1<sup>st</sup> International Conference on Civil and Environmental Engineering for Resilient, Smart and Sustainable Solutions**

**Potentials for automated measurement  
of the soil shrinkage characteristics  
by an optical method**

**Lorenz Spillecke\***

**Dr. Alexander Knut**

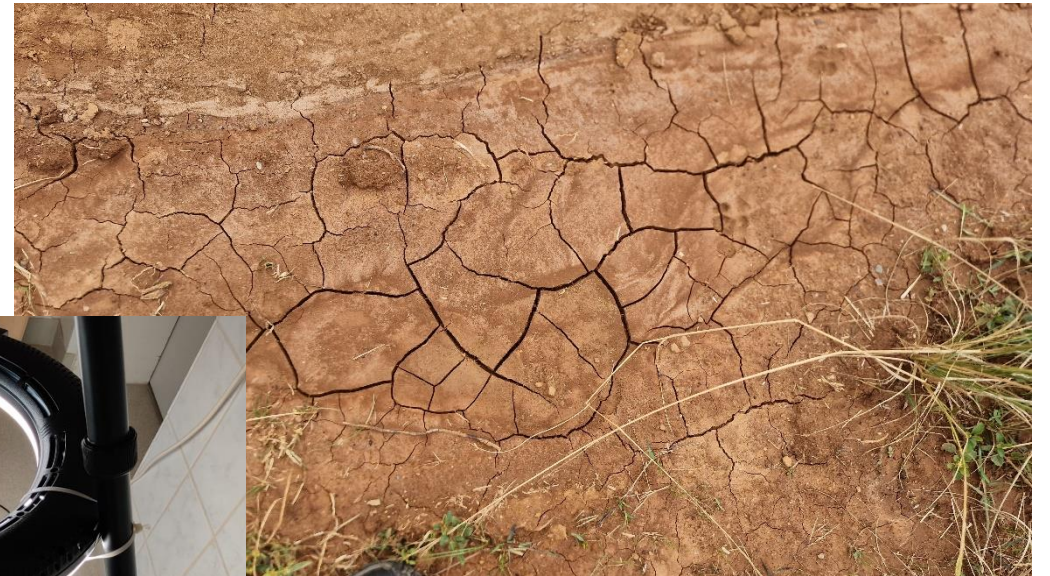
**Hermann Busse**

**Prof. Dr. Antje Bornschein**

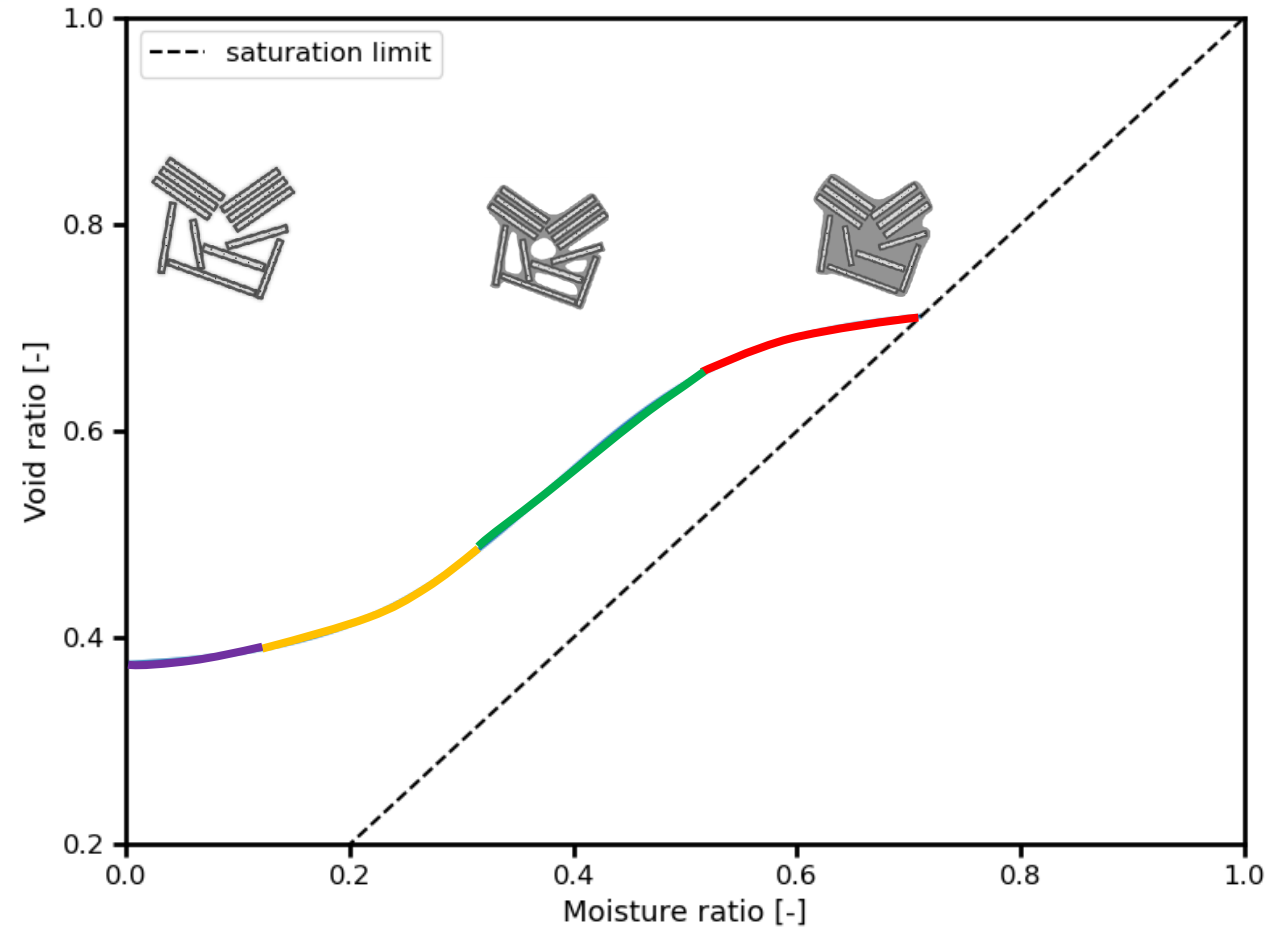
**Prof. Dr. Ralf Thiele**

# Introduction

*“...annually damage cost, originated from the shrink and swell behaviour of expansive soils, has risen dramatically to over \$13 billion per year in the United States.” - 2009*



# Introduction



## *Structural shrinkage:*

- *Macro pores desiccate*

## *Proportional shrinkage:*

- *Linear shrinkage phase*
- *moisture loss equals void ratio loss*

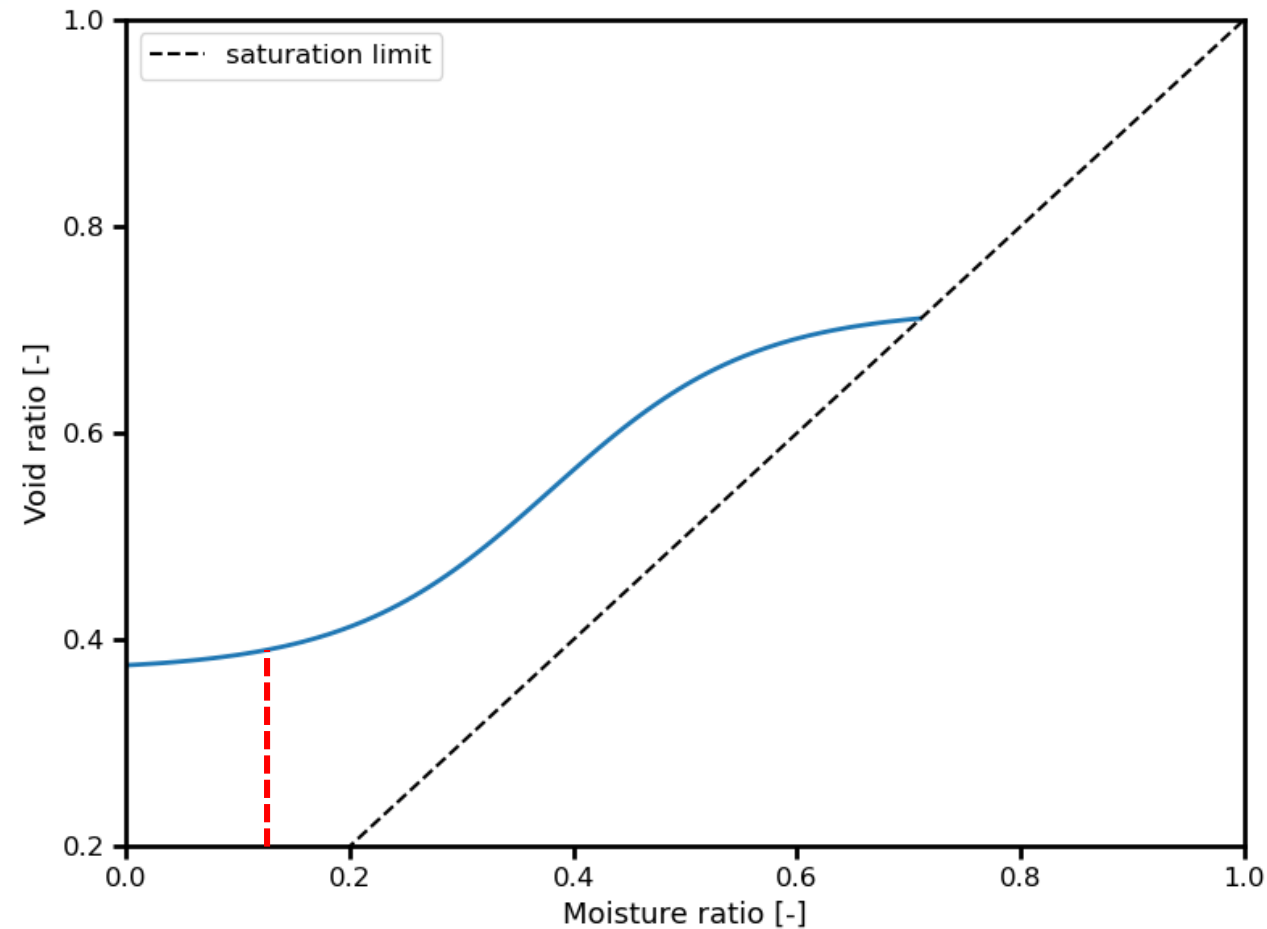
## *Residual shrinkage:*

- *exceeding moisture loss translates to less shrinkage*

## *Zero shrinkage:*

- *Nearly zero deformation*

# Shrinkage limit



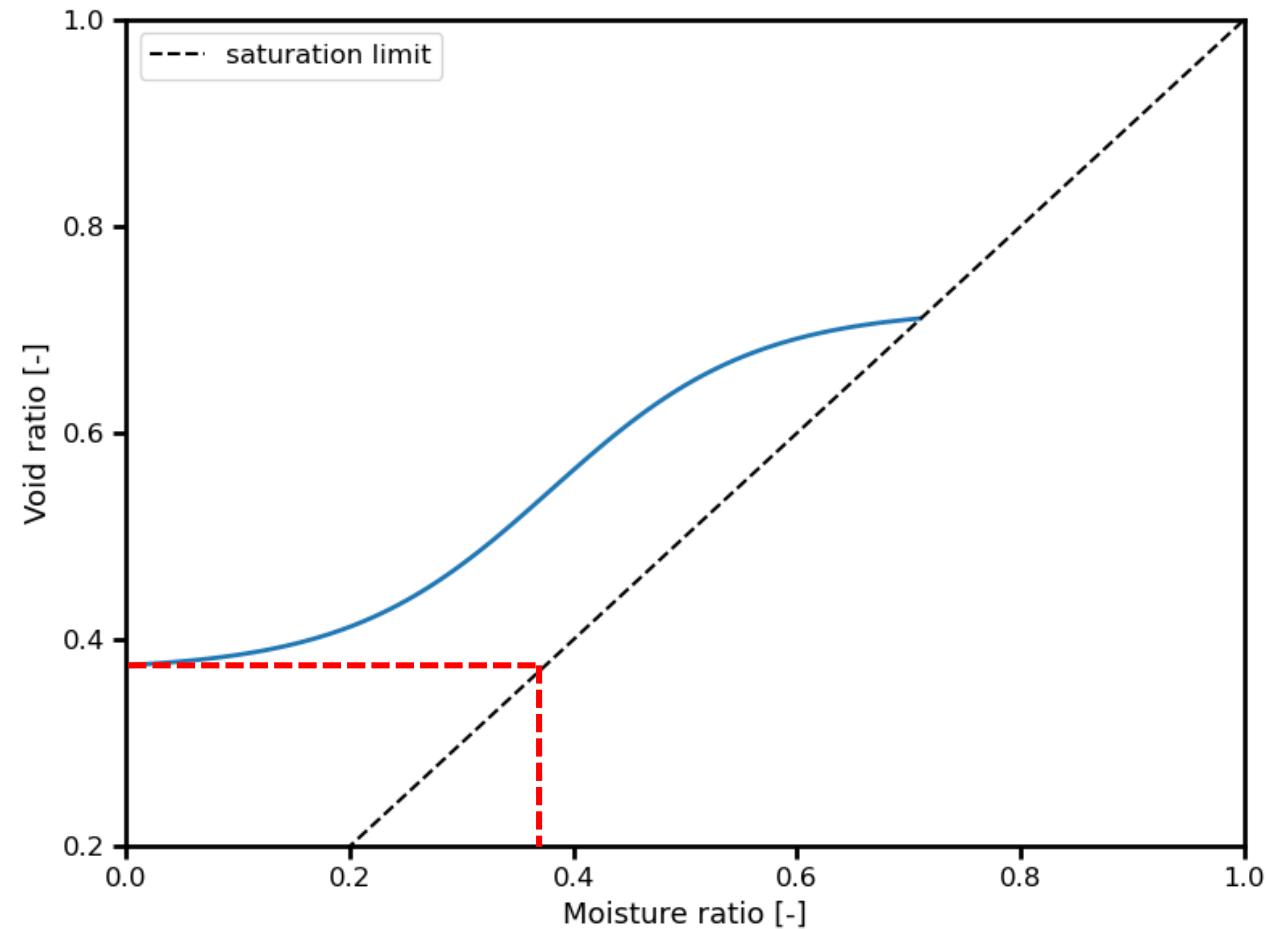
*The shrinkage limit is defined as the water content, beneath which almost no further volume change occurs despite further drying*

*Liquid limit -> plastic – liquid*

*Plastic limit -> semi solid – plastic*

***Shrinkage limit -> solid – semi solid***

# Standards for shrinkage limit determination



*DIN EN 18122-2*

$$w_S^{norm} = \left( \frac{V_D}{m_s} - \frac{1}{\rho_s} \right) \rho_w$$

*ASTM D4943-18*

$$w_s = w - \left[ \frac{(V - V_d)\rho_w}{m_s} \right] \times 100$$

$w_s$  = shrinkage limit

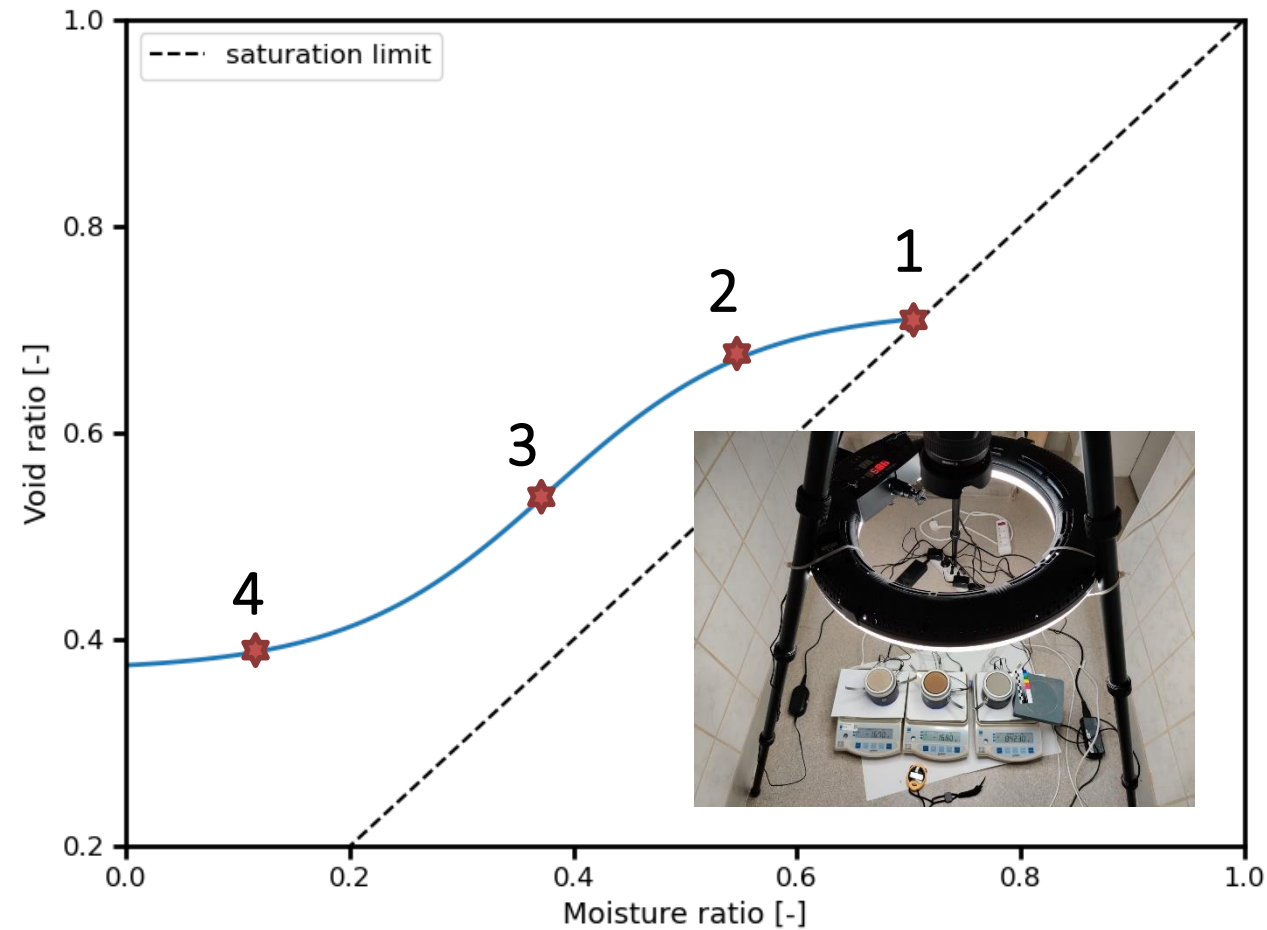
$w$  = initial water content

$V$  = volume of wet soil

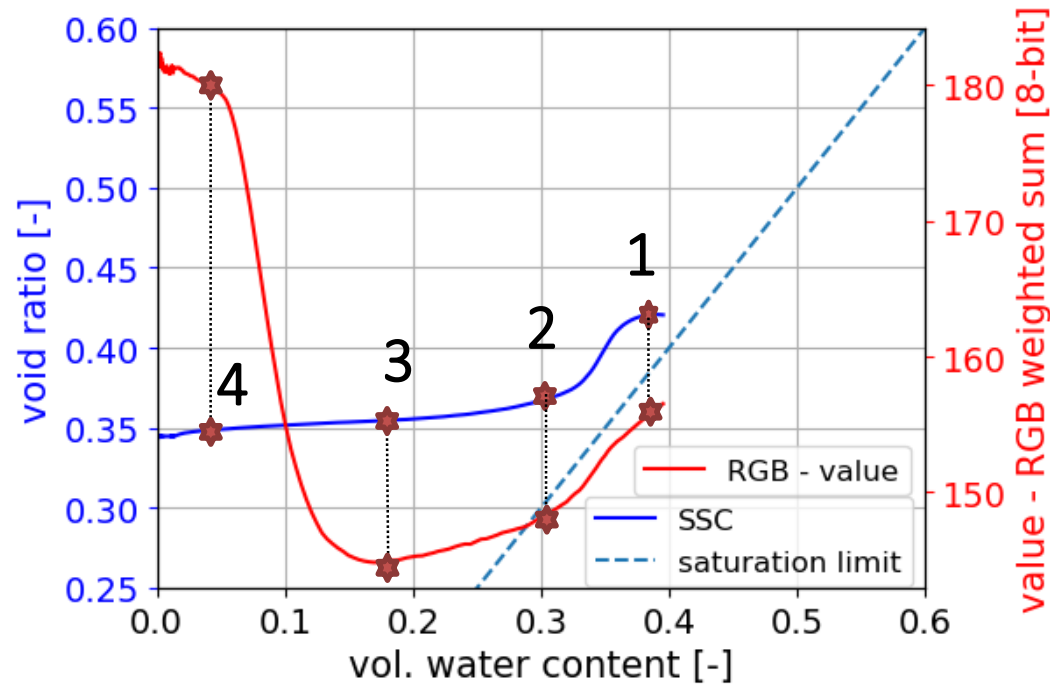
$V_d$  = volume of dry soil

$m_s$  = dry mass soil

# Laboratory investigation



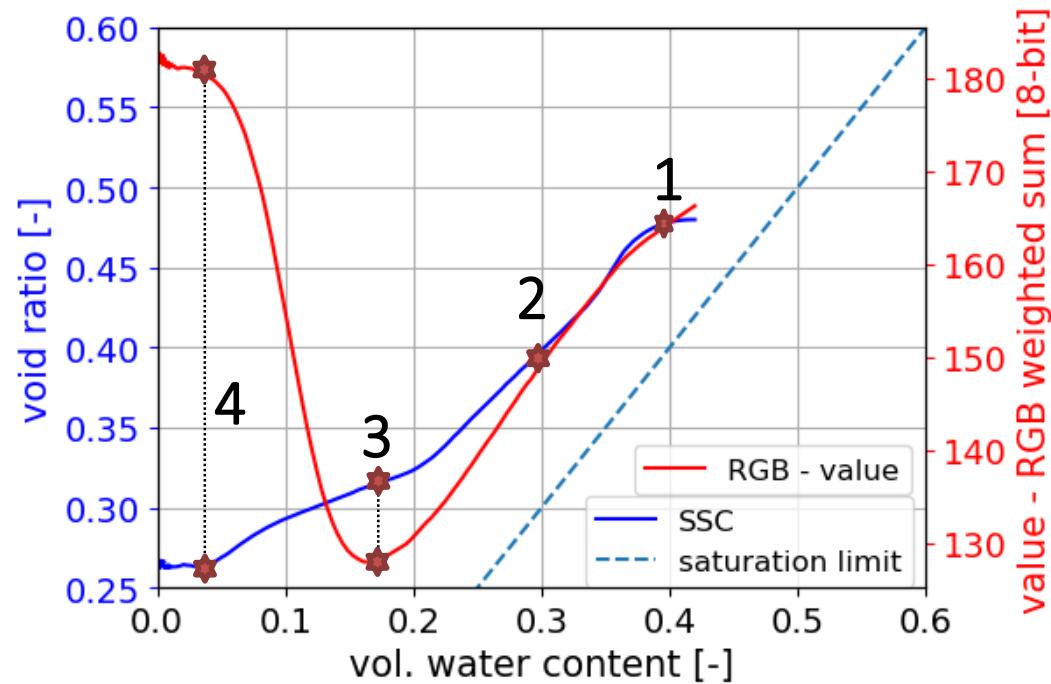
# Results



|                          |          |
|--------------------------|----------|
| Sand/Silt/Clay [%]       | 62/25/13 |
| Liquid limit [vol. %]    | 32.80    |
| Plastic limit [vol. %]   | 28.20    |
| Shrinkage limit [vol. %] | 32.20    |



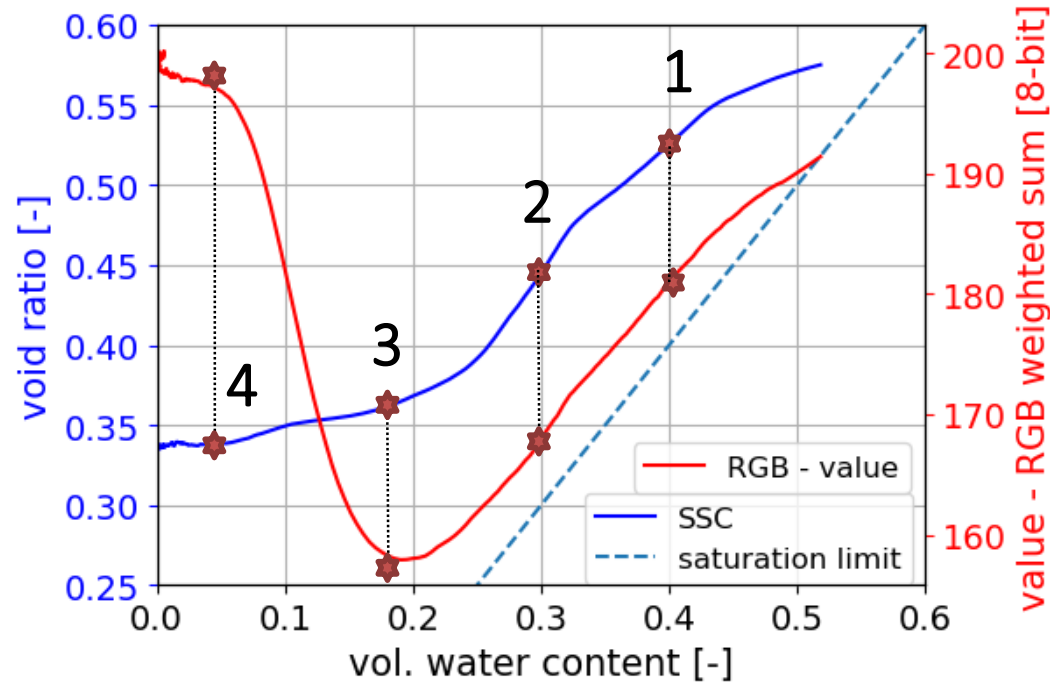
# Results



|                         |          |
|-------------------------|----------|
| Sand/Silt/Clay [%]      | 58/26/16 |
| Liquid limit [vol. %]   | 37.80    |
| Plastic limit [vol. %]  | 21.10    |
| Shrinkage limit [vol %] | 26.00    |



# Results



|                          |          |
|--------------------------|----------|
| Sand/Silt/Clay [%]       | 20/37/43 |
| Liquid limit [vol. %]    | 50.00    |
| Plastic limit [vol. %]   | 24.60    |
| Shrinkage limit [vol. %] | 34.00    |



# Outlook

## *Potentials for an optical measurement method*

