Experimental determination of the Constriction Size Distribution for granular filters

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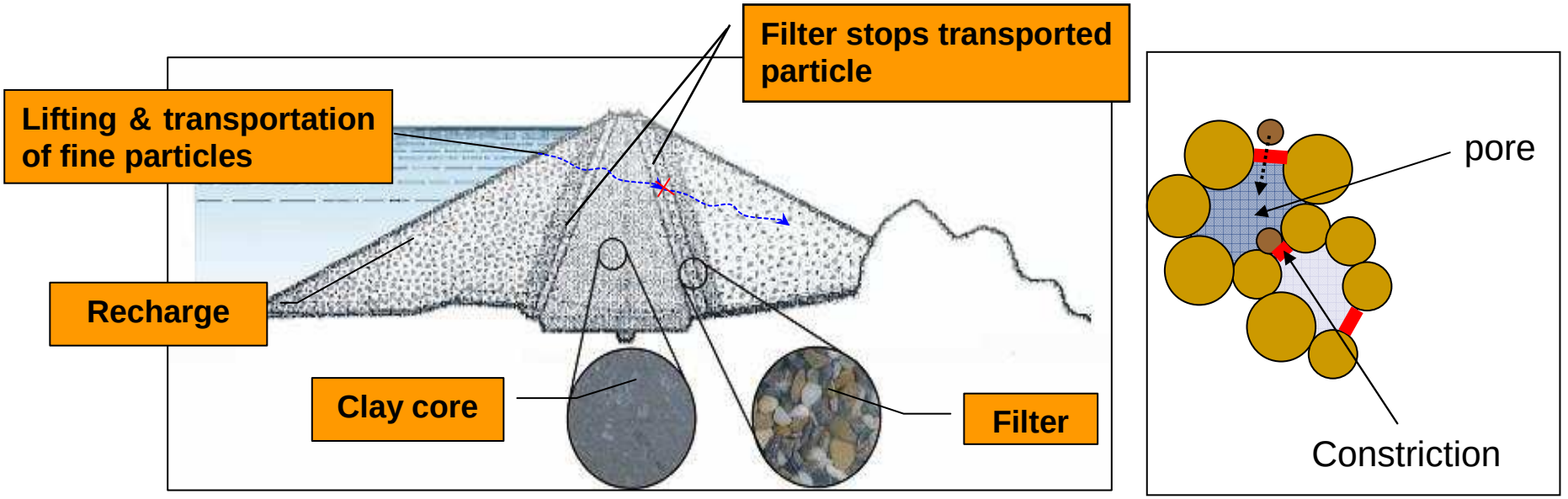
ANR-PN

Context

Maintenance and sustainability of earth dams

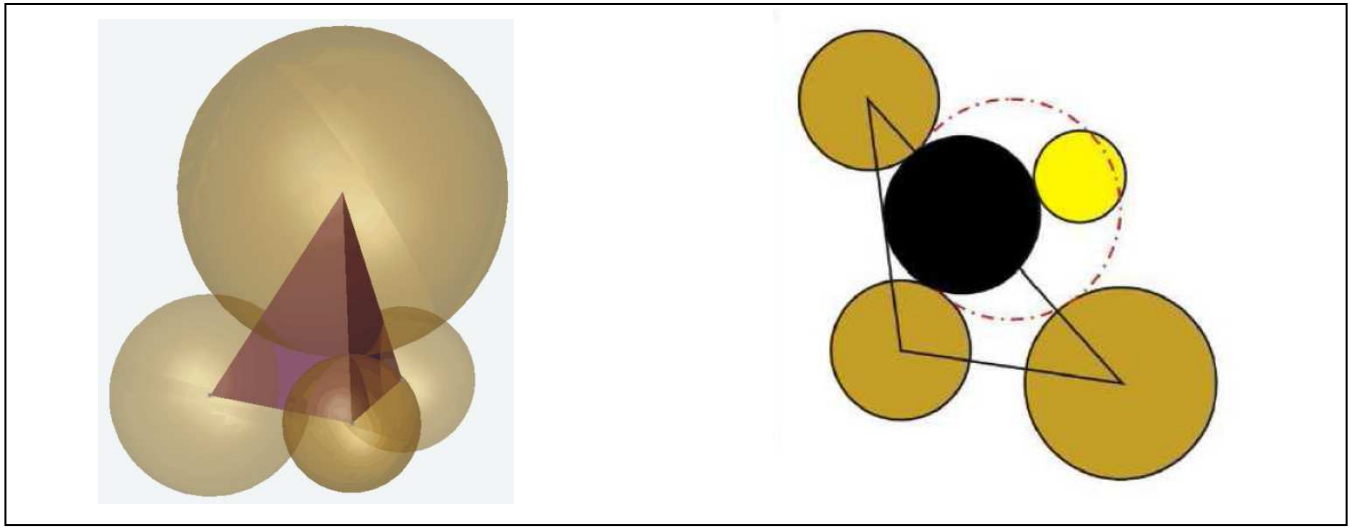


Question

How to experimentally determine the Constriction Size Distribution (CSD) ?

Discrete Element Method + Delaunay Tessellation (DEMDT)

Reboul et al. (2008)

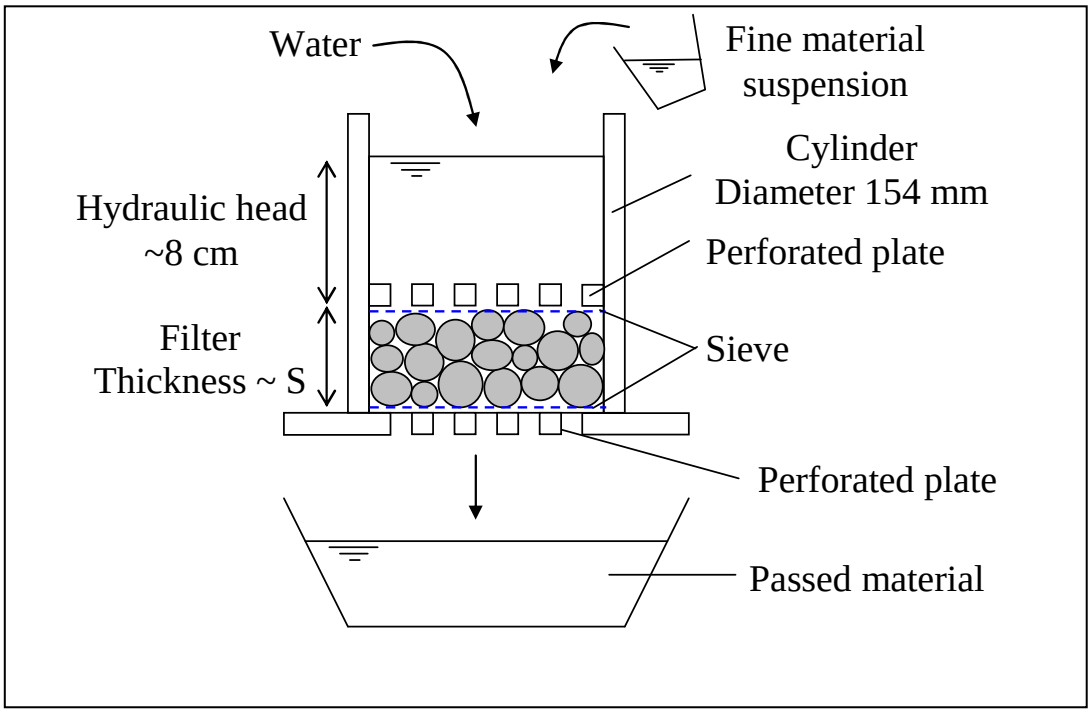


- The **pore volumes** can be defined as the void volume in each tetrahedron
- The **constriction size** is defined as the diameter of the largest empty disc included on a tetrahedron face and included in the void space.

Device

- Experimental filtration tests of fine particles by a filter of different thicknesses
- Relation between the grading of fine particles able to cross the filter and the CSD
- Use of a probalistic model focusing on the path of the largest representative collected fine particle

Soria et al. (1993)



Base soil

Sjah et Vincens, 2012

- Linear grading

- d_{100}

uniformly graded materials, say $U_c < 2$

whatever the density of the filter: $d_{100} = D_0$

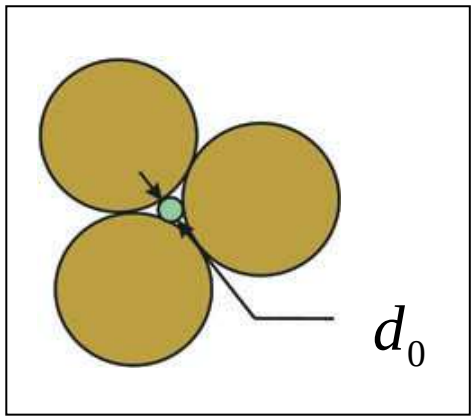
well graded material, say $U_c \geq 2$

loose states: $d_{100} = \sqrt{U_c}.D_0$

dense states: $d_{100} = D_0$

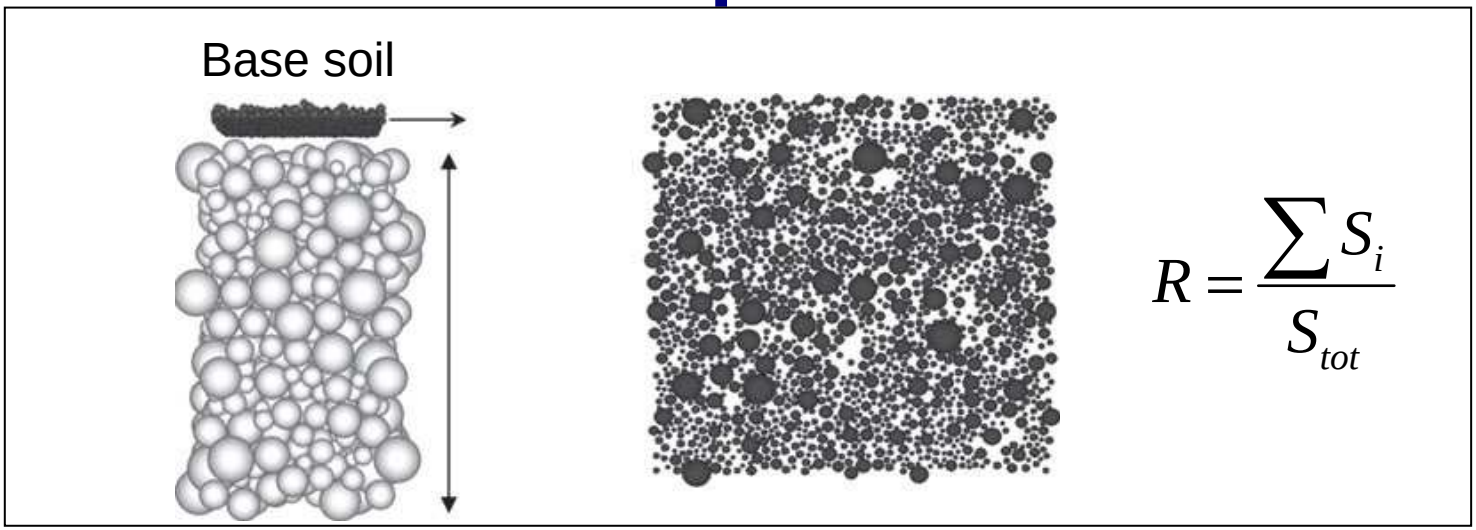
- d_0

equal to the smallest constriction : $d_0 = \frac{D_0}{6.5}$



Sjah et Vincens, 2012

Number of particles



- R = 125% is correct even if interactions exist between small particles

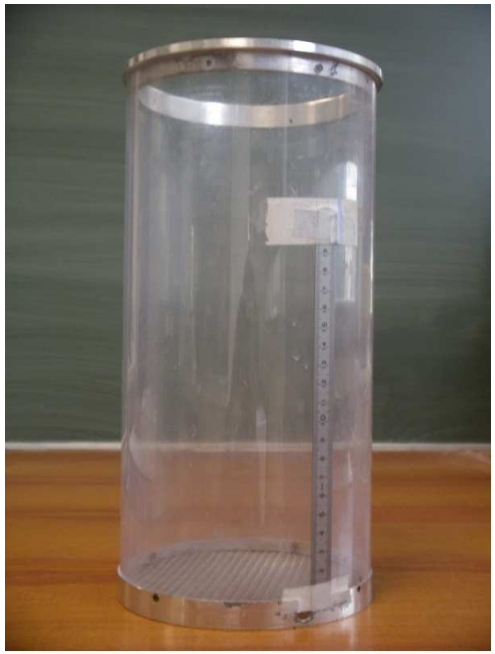
Hydraulic head

- Reynolds number **greater than 35** to remove meta stable trapped fine particules (Muresan et al., 2010)

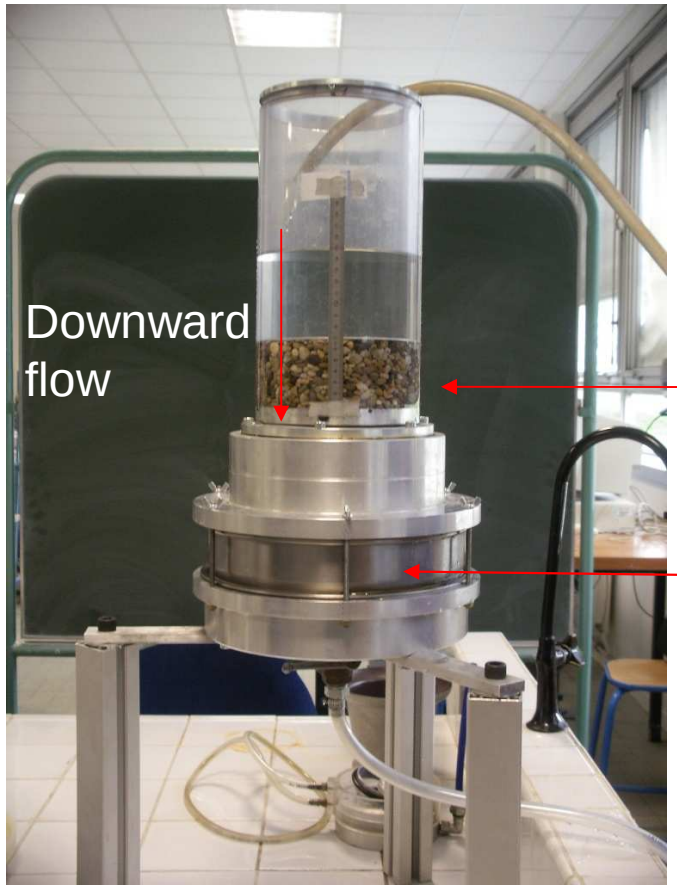
→ Level of water at 10cm above the sample to guide the poured fine particles

Device

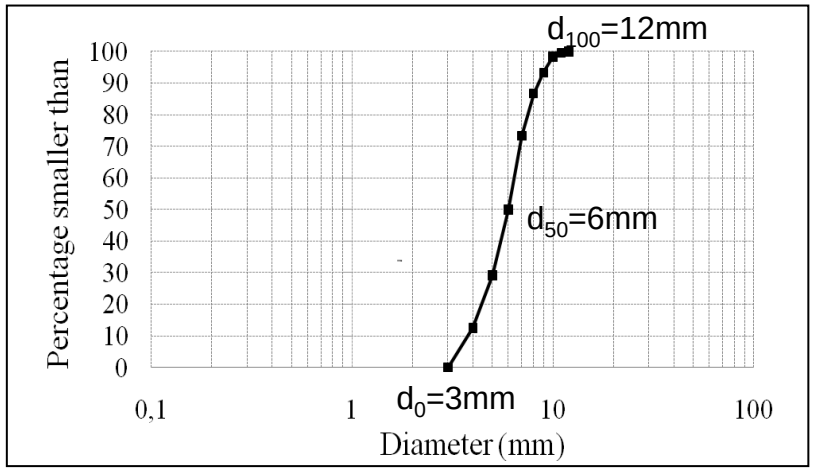
Mobile part for the sample



Overall device



Materials



Particle size distribution

Glass beads

$e_{max} \approx 0.71$

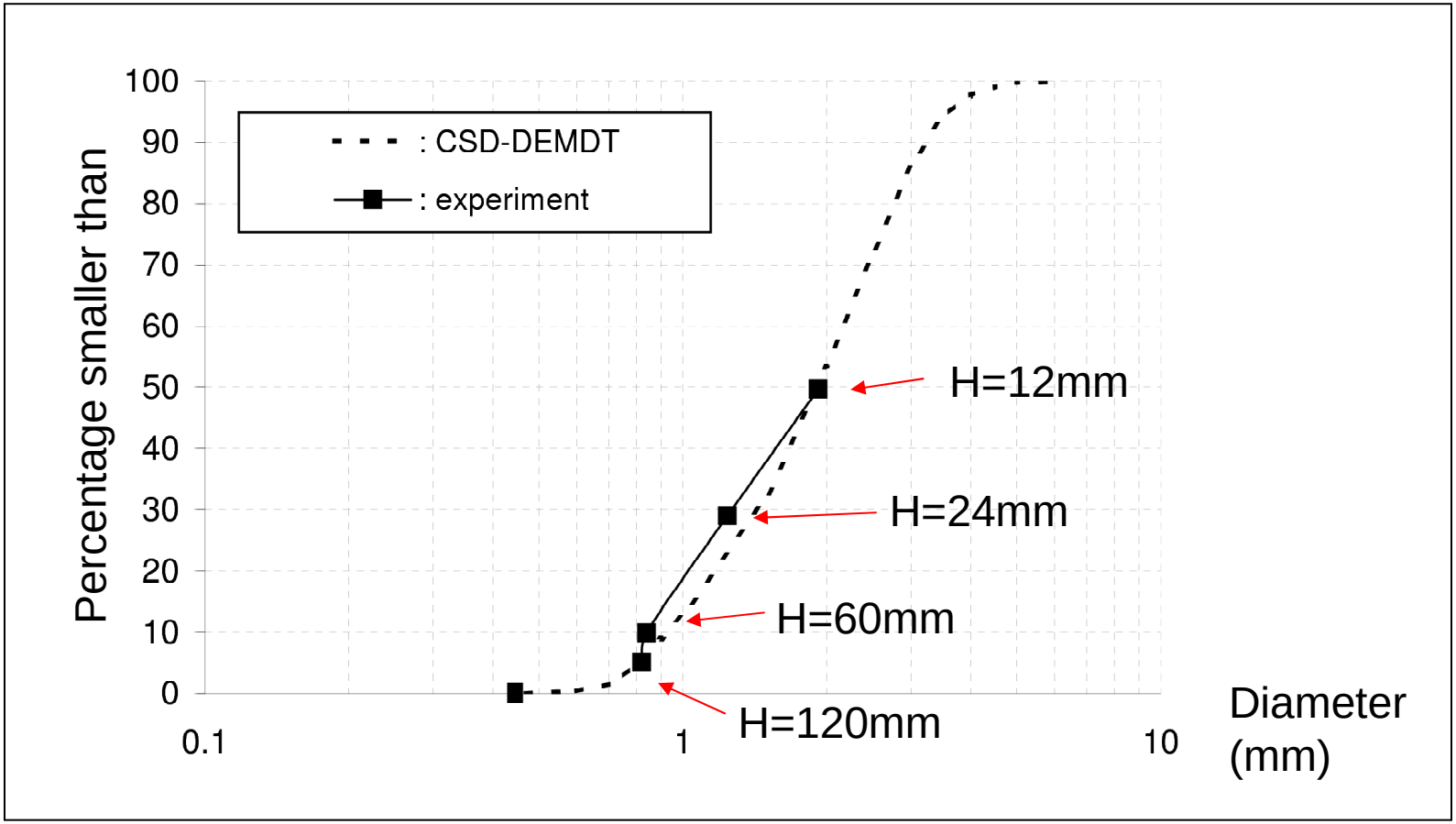
Sub rounded

$e_{max} \approx 0.69$

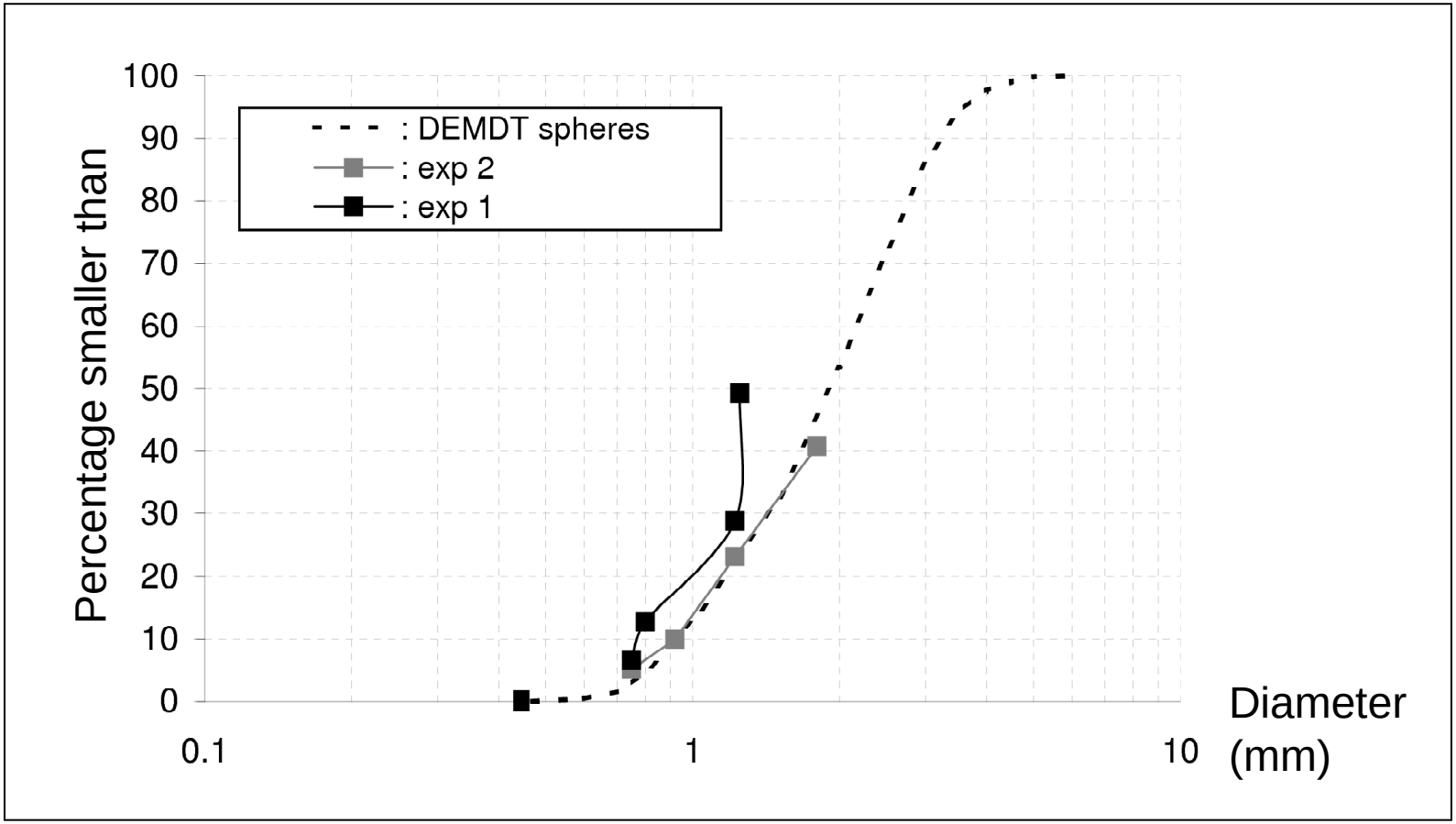
Sub angular

$e_{max} \approx 0.95$

CSD for glass beads - validation

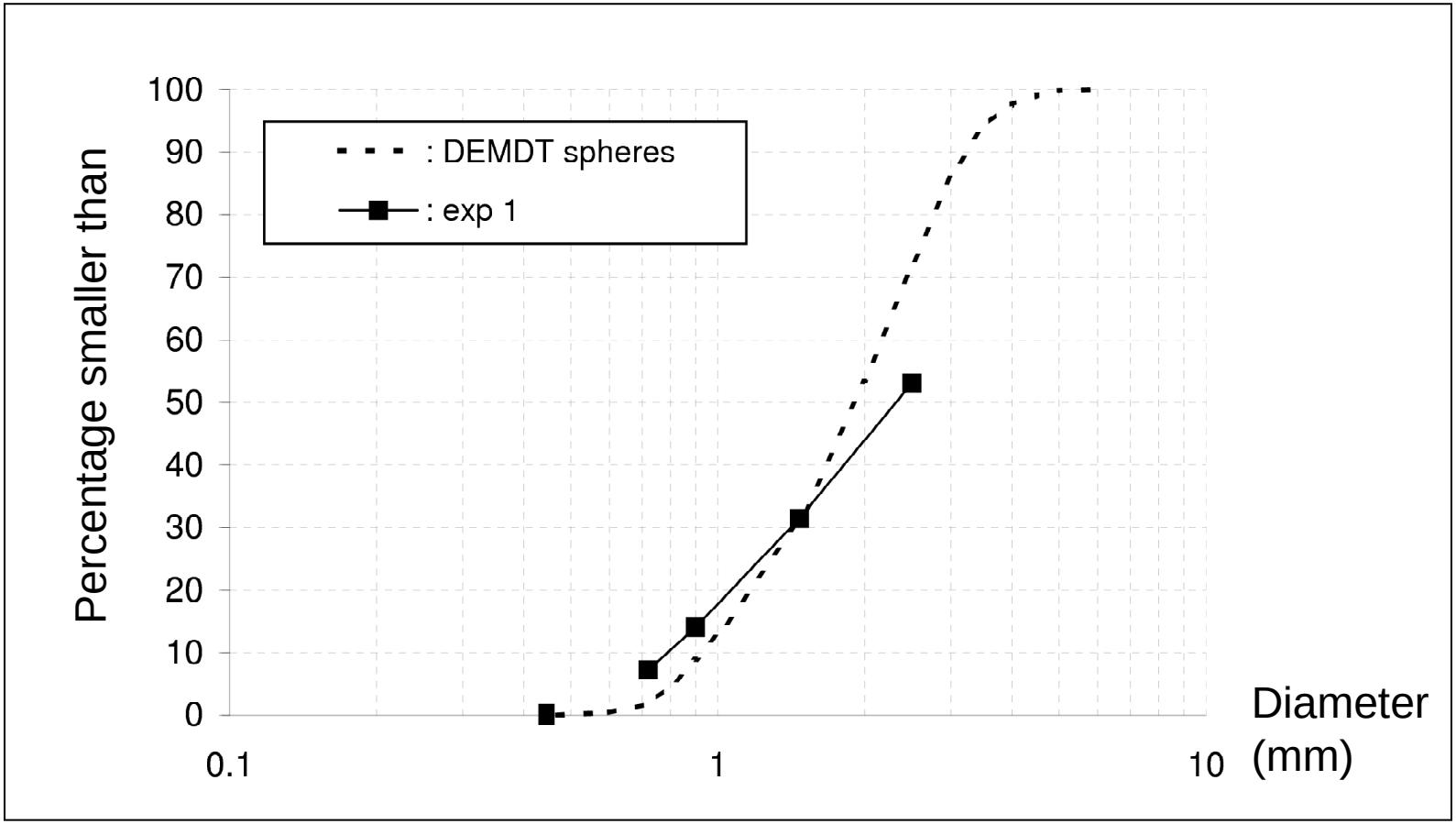


CSD for sub rounded material



e_{max} similar to glass beads → similar CSD

CSD for angular material



Tendencies need to be confirmed: relatively same shape for the CSD

greater proportion of small constrictions

larger constrictions

Conclusion

- Device to compute the CSD of a granular filter
- Experiments with glass beads leads to a CSD similar to DEMDT and DEM simulations (not shown herein)
- **50% smaller of the CSD** can only be obtain
- for rounded particles, **CSD similar to glass beads**
- for angular particles, **CSD is not that different that the one for glass beads**… though the void ratio is quite different… need to be confirmed

Question

- Are the results directional… direction of the seepage with respect to the anisotropy of the solid skeleton ?