Damage of sewer pipes: the interaction with soil

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Problem statement

Danger of sewer collapse

Premature replacement

Goal

Provide an accurate tool to assess the condition of a sewer pipe to help municipalities make a decision on maintenance or replacement

Research question

What is the expected lifetime of an in-situ deteriorated sewer pipe?

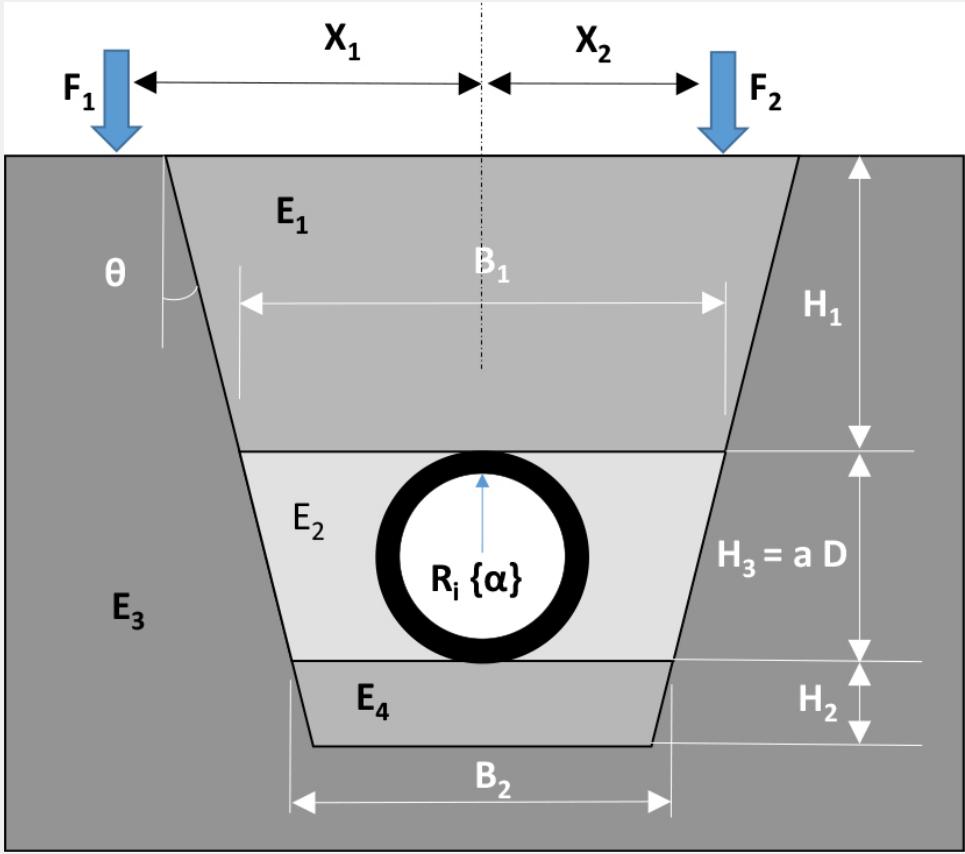
www.keckplumbing.com

Sewer system

Pipe in soil trench

Dutch soils: sand, clay, peat, loam

Strength of system: pipe + soil



Soil Erosion

Loss of support

Washing away of particles

Soil ingress in pipe

Hard to detect

www.slocity.org

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Damage of pipe

Chemo-mechanical deterioration

Emergence of micro-cracks

Collapse due to

Nearby excavations

Change in external loading

Severe deterioration of concrete

Loss of support

www.avalons.net

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Research question

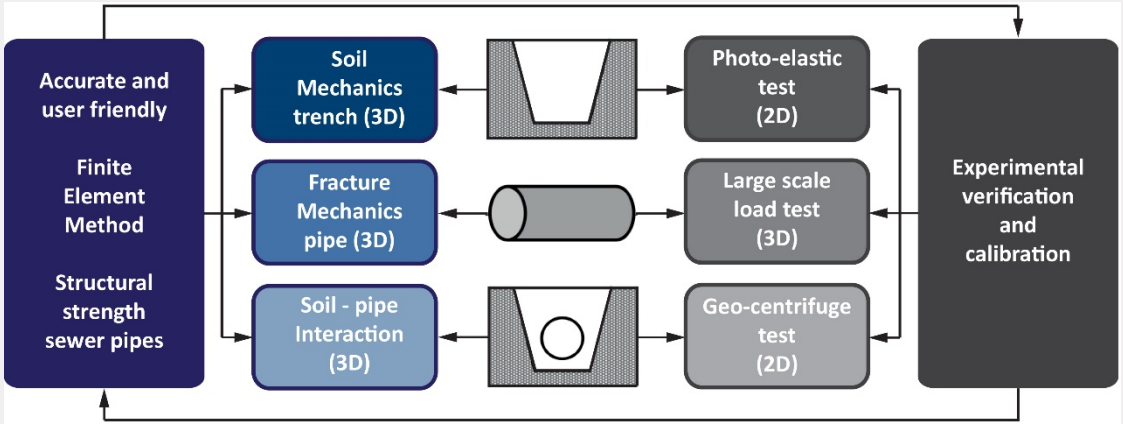
What is the expected lifetime of an in-situ deteriorated sewer pipe?

What we need to investigate

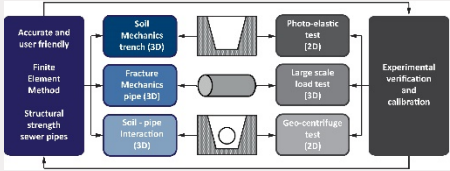
Process of deterioration

Relation damage – residual strength of pipe

Relation soil – strength of system

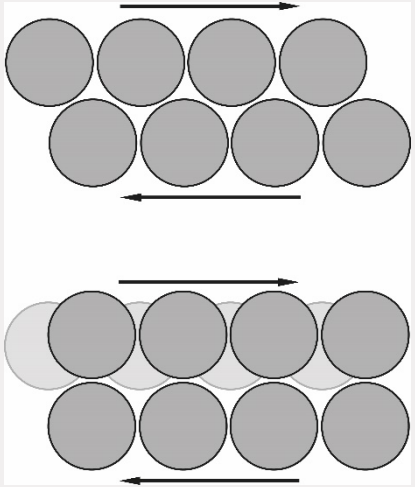


Soil Mechanics trench (3D)

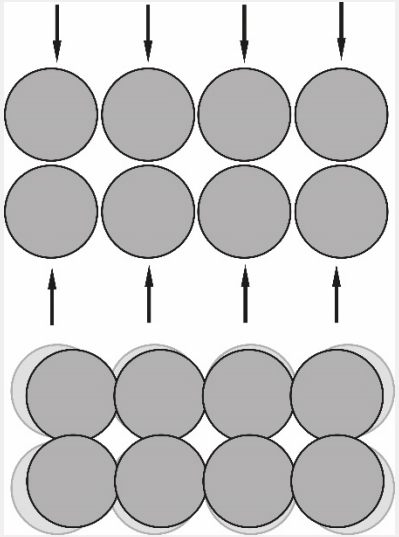


Soil modelling

Friction sliding



Volumetric compaction



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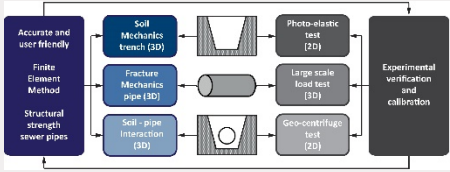


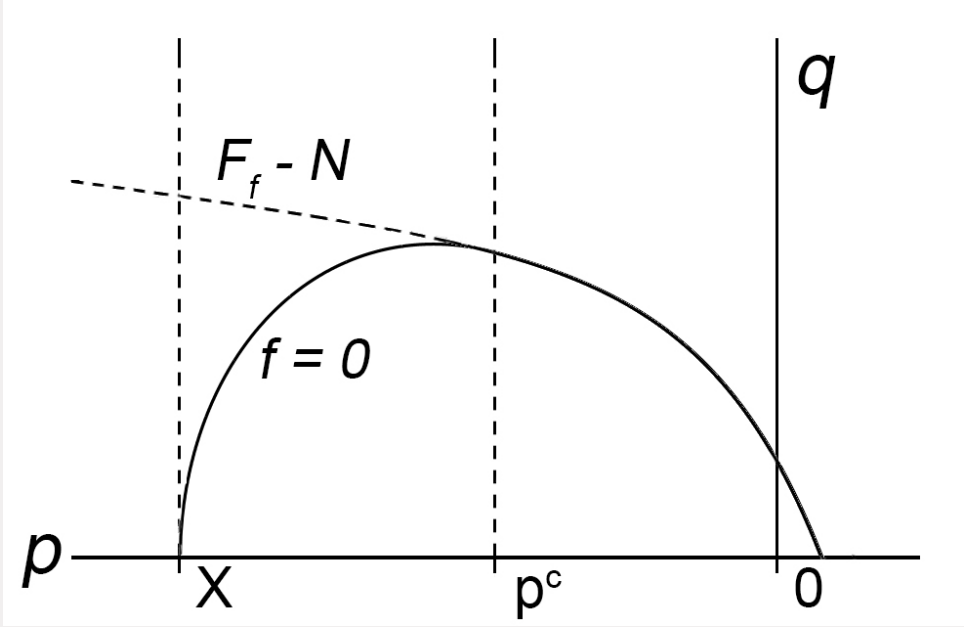
Numerical approach (FEM)

Yield surface

Boundary between reversible and irreversible deformations

Reversible: elastic deformation of particles

Irreversible: frictional sliding, particle crushing (volumetric compaction)



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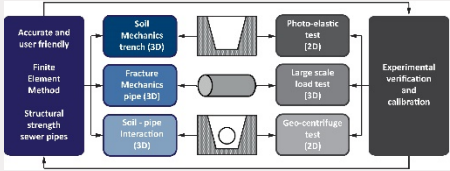
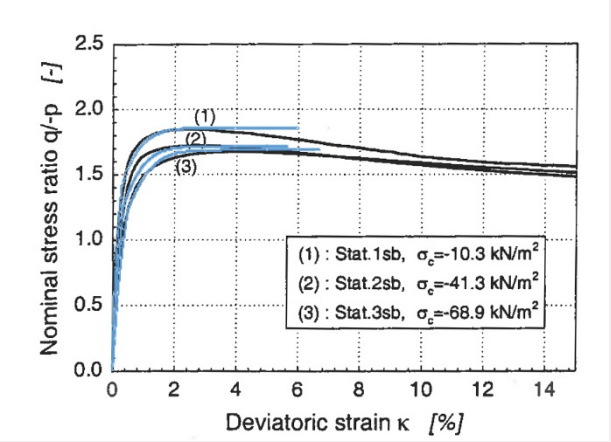
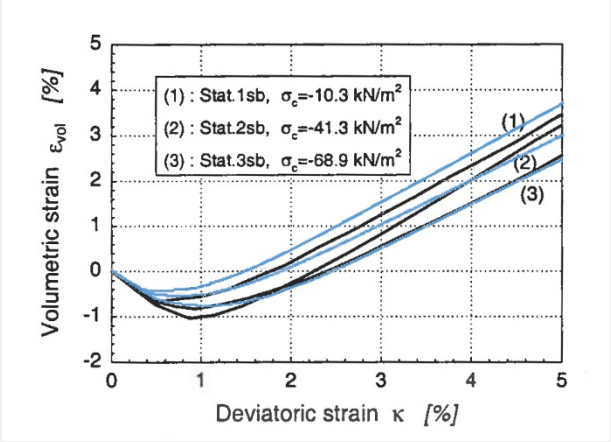


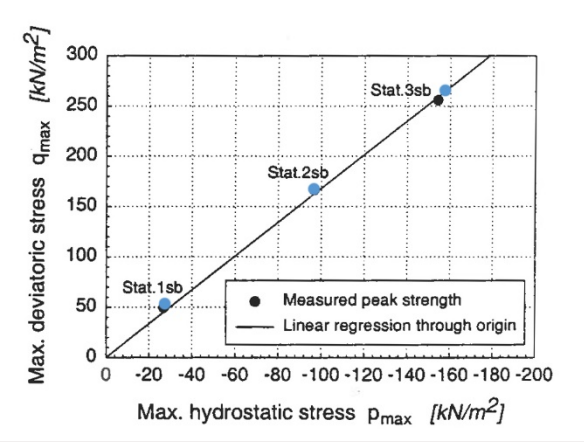
Results soil model

Comparison experimental results

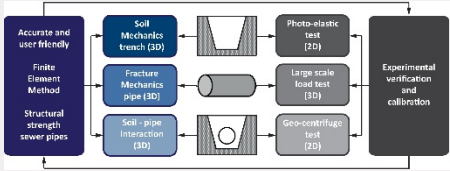
Suiker, A., Selig, E., and Frenkel, R. (2005). Static and cyclic triaxial testing of ballast and subballast. *Journal of geotechnical and geoenvironmental engineering*, 131:771-782.





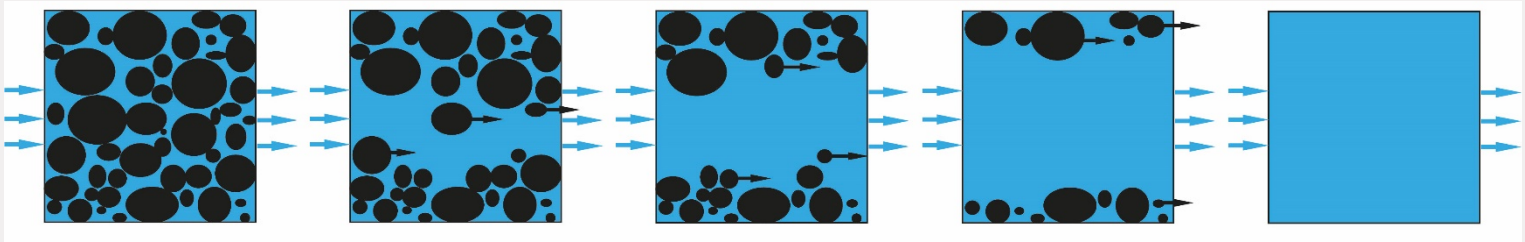


Soil Mechanics trench (3D)



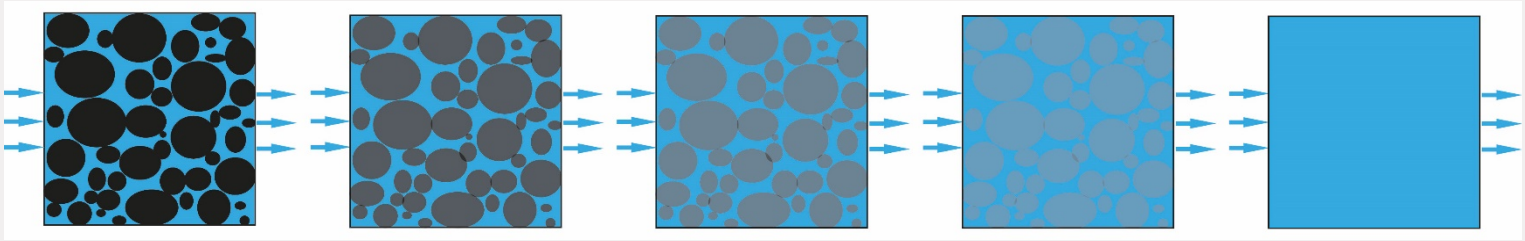
Characteristic of erosion

Washing away of particles



Numerical approach

'Fading' of particles



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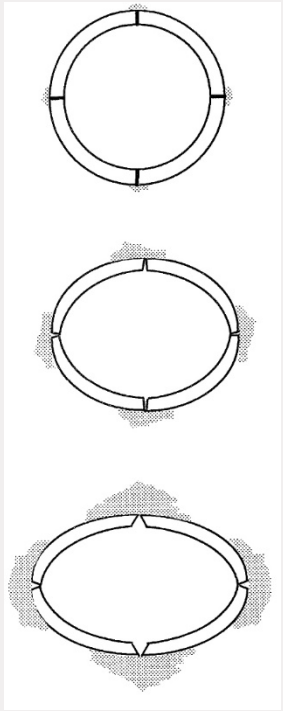
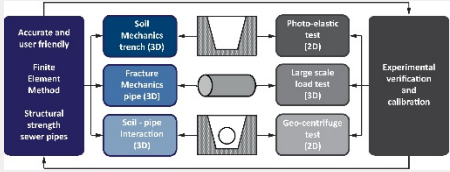
Characteristics of fracture of sewer pipe

First cracks at bottom and top

Later damage at sides

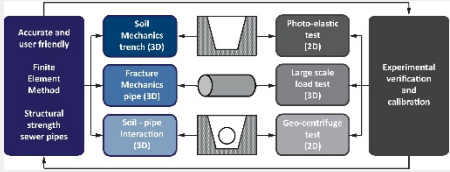


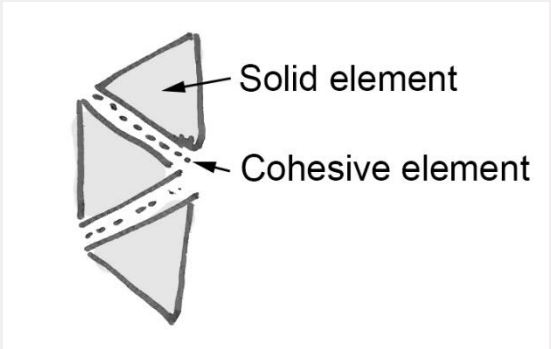
Fracture Mechanics pipe (3D)

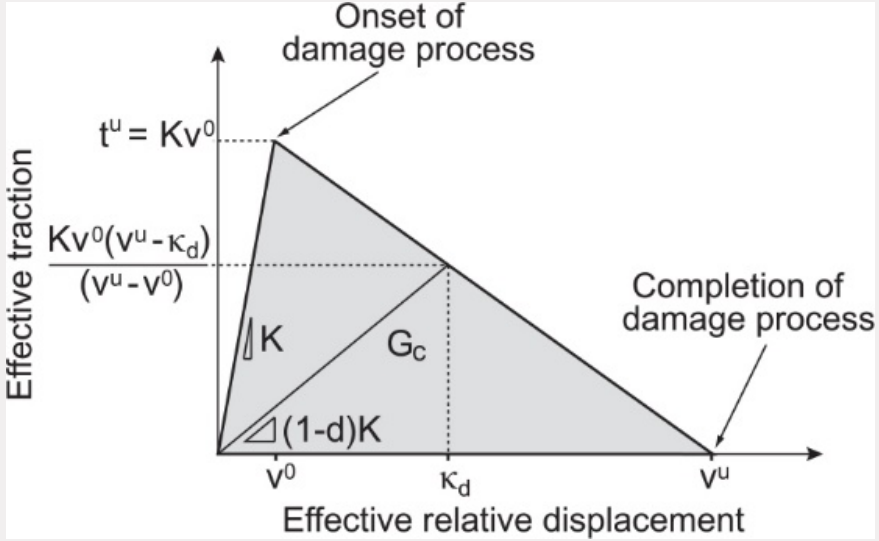


Numerical approach

Cohesive zone modelling







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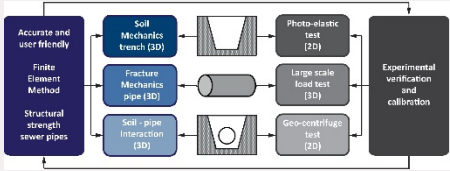
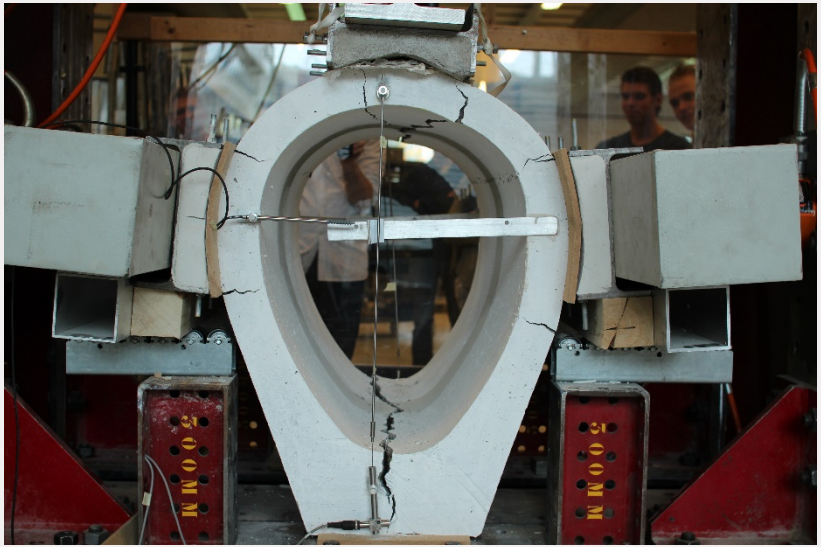
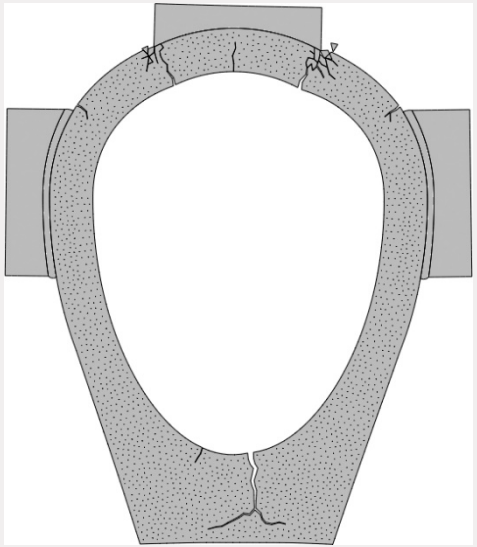


Preliminary results

Comparison experimental results

Stanic, N., Langeveld, J., Salet, T., Clemens, F. (2017). Relating the structural strength of concrete sewer pipes and material properties retrieved from core samples. *Structure and Infrastructure Engineering*, 13:637-651.





Future work

Relate amount of damage to residual strength of pipe

Large scale load test on pipes

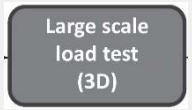
Small test on pipe samples to assess material properties

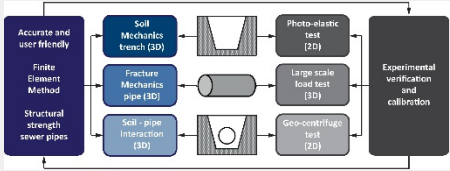
New and old pipes

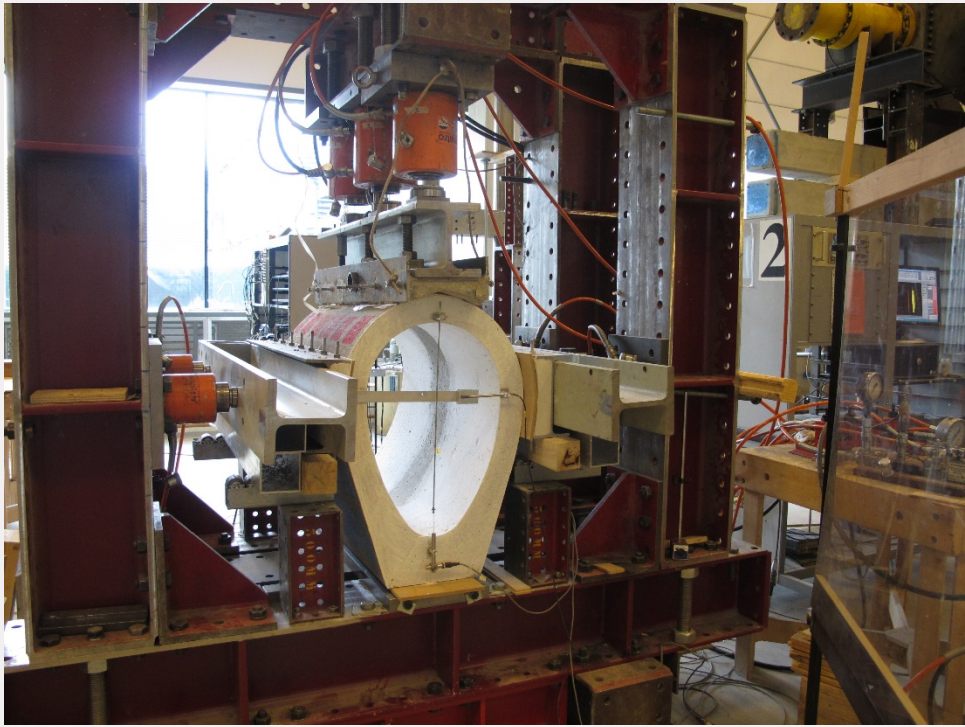
Round and egg-shaped

Several diameters

Different ages







Questions?