VIENNA

Time Capsule Project (TCP)

Austrian Geotechnical Society

ÖIAV
AUSTRIAN ASSOCIATION OF ENGINEERS AND ARCHITECTS

SIMSG ISSMGE

SIMSG ISSMGE Time Capsule Project (TCP)
PAST PRESENT FUTURE

AUSTRIA

Introduction

This series of slides presents a selection of important achievements and activities of the Austrian Geotechnical Society as part of the *Time Capsule Project* launched by the ISSMGE.

The **past** is covered by featuring the early days of soil mechanics in the 1920s when Karl von Terzaghi was Professor in Vienna where he established a soil mechanics laboratory together with his co-workers. Some decades later the Institute of Soil Mechanics, Rock Mechanics and Foundation Engineering was established at Graz University of Technology under the leadership of Professor Christian Veder.

Moving towards the **present** Professor Heinz Brandl has to be mentioned who pioneered the integration of Eastern European Countries into the ISSMGE when the iron curtain was still a barrier for free travel.

Looking into the **future** ongoing research activities of key university institutes of geotechnics are highlighted showing a variety of topics covering many aspects of soil mechanics, geotechnical engineering and computational geotechnics.

A list of selected international projects where specialist contractors based in Austria are involved demonstrates that Austrian technology is applied world wide.

Finally the Austrian section of the Young Member Presidential Group present their way into the **future**.

The contribution towards this presentation of many colleagues, active in the Austrian Geotechnical Society, is gratefully acknowledged.

Helmut F. Schweiger
President Austrian Geotechnical Society

Content

- **Personalities**
  - Karl von Terzaghi
  - Christian Veder
  - Heinz Brandl
- **Past and Current Research Activities**
  - TU Wien (TUW)
  - Graz University of Technology (TUG)
  - University of Innsbruck (UIBK)
  - University of Natural Resources and Life Sciences, Vienna (BOKU)
- **Miscellaneous**
  - International Projects of Specialist Contractors
  - Young Member Presidential Group
  - Conferences
  - Bid for 21st ICSMGE 2026 in Vienna

PAST

FUTURE

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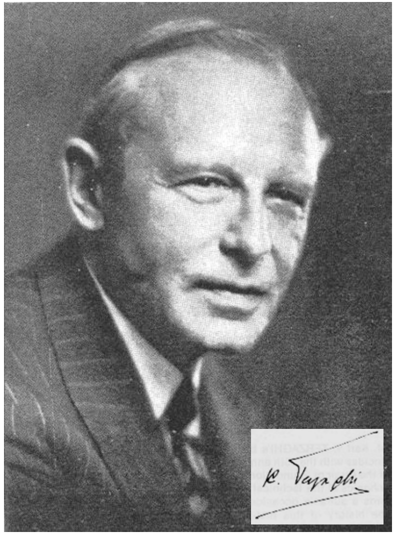
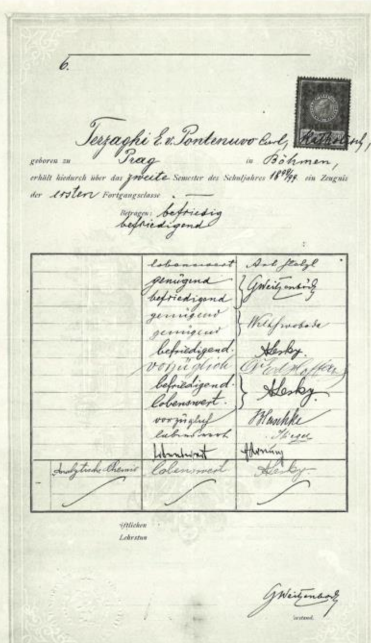
PAST

FUTURE

Personalities: Karl von Terzaghi Professor at Vienna Technical University 1929-1938



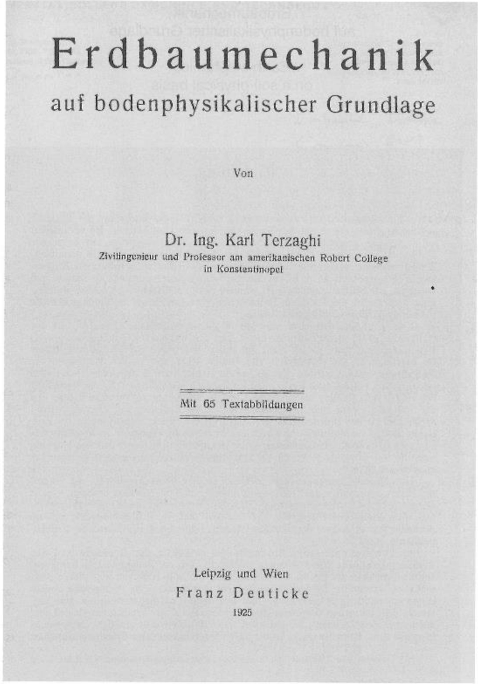
Karl v. Terzaghi 1883-1963



Terzaghi E. v. Pontenuovo Carl,
geboren zu Prag in Böhmen,
erhält hiedurch über das zweite Semester des Schuljahres 1898/99 ein Zeugnis der ersten Fortgangsclasse

Betragen: befriedig befriedigend

School report 1898/99 (Graz)



Erdbaumechanik

auf bodenphysikalischer Grundlage

Von

Dr. Ing. Karl Terzaghi
Zivilingenieur und Professor am amerikanischen Robert College in Konstantinopel

Mit 65 Textabbildungen

Leipzig und Wien
Franz Deuticke
1925

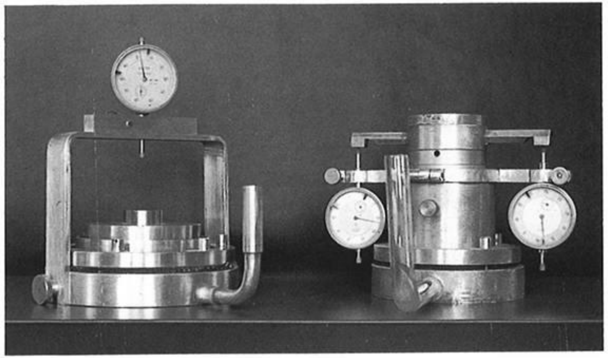
Cover page of Professor K.Terzaghi´s fundamental book.

Source:
H. Brandl - *Prof.Dr.Dr.h.c.mult. Karl v. Terzaghi*
H. Brandl - *History of the Institute for Foundation Engineering and Soil Mechanics at the Vienna Technical University*
Technische Universität Wien - Mitteilungen für Grundbau, Bodenmechanik und Felsbau (1983-1984)

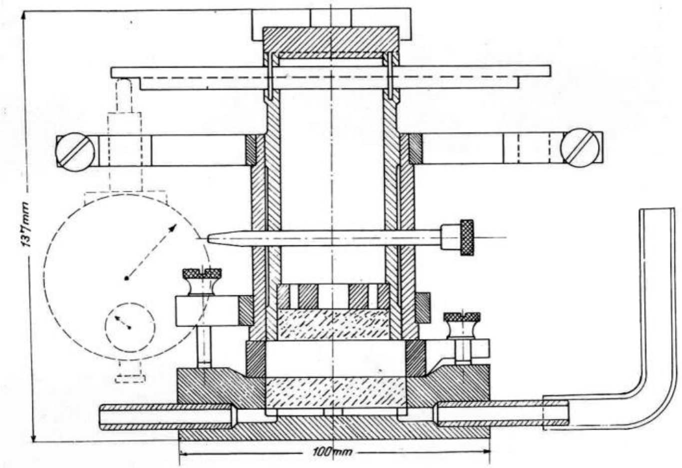
https://de.wikipedia.org/wiki/Karl_von_Terzaghi

Personalities: Karl von Terzaghi Professor at Vienna Technical University 1929-1938

Arthur Casagrande: Head of Soil Mechanics Laboratory 1929-1932



Original of first oedometer



Original drawing of oedometer

Source:
H. Brandl - *Prof.Dr.Dr.h.c.mult. Karl v. Terzaghi*
H. Brandl - *History of the Institute for Foundation Engineering and Soil Mechanics at the Vienna Technical University*
Technische Universität Wien - Mitteilungen für Grundbau, Bodenmechanik und Felsbau (1983-1984)

Time Capsule Project (TCP)

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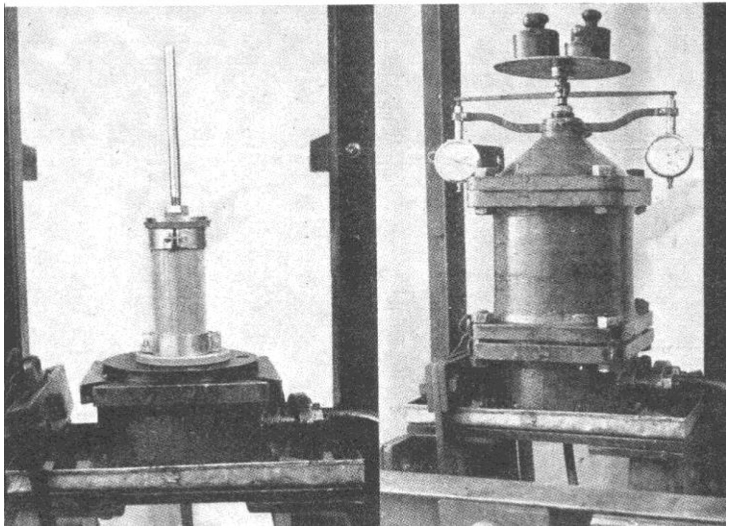
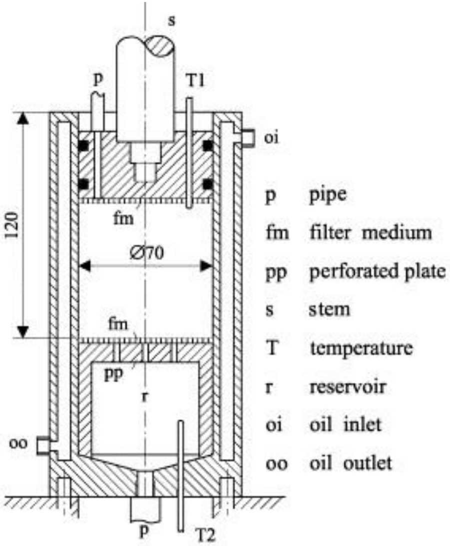
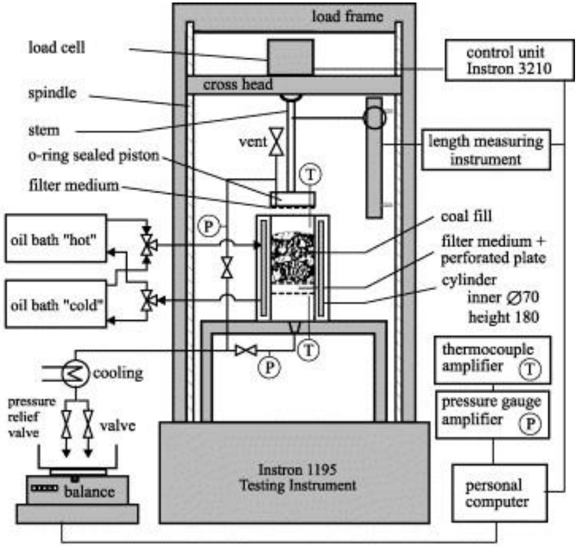
Arthur Casagrande: Head of Soil Mechanics Laboratory 1929-1932



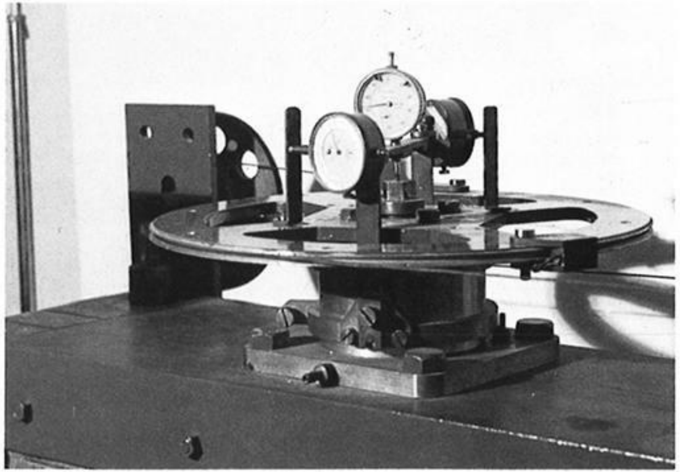




First triaxial compression apparatus, 1934

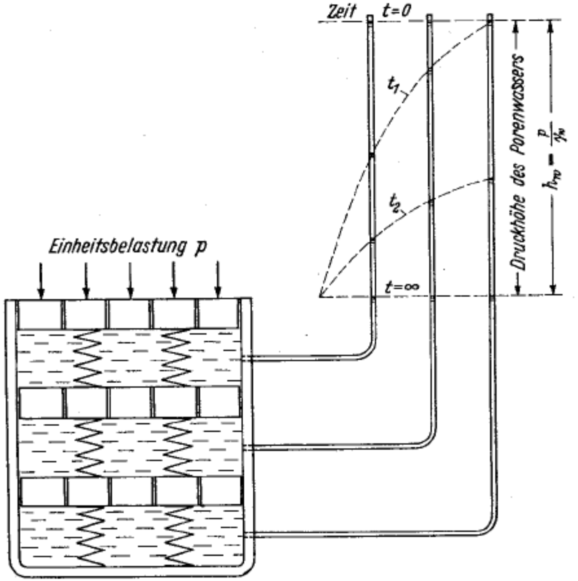
Personalities: Karl von Terzaghi Professor at Vienna Technical University 1929-1938

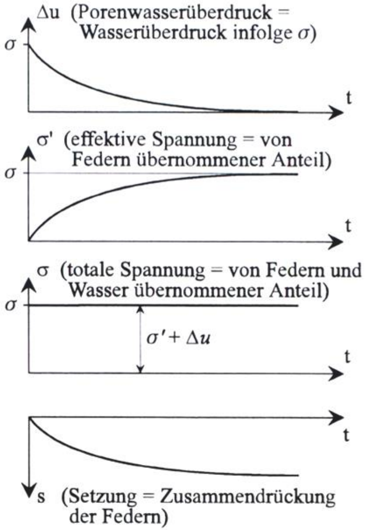
Terzaghi's Laboratory



First ring shear apparatus, 1934

Personalities: Karl von Terzaghi Professor at Vienna Technical University 1929-1938





$$\frac{\partial}{\partial t}\left(\frac{\Delta l}{l}\right) = \nu \frac{\partial p}{\partial t} = \frac{k}{\gamma} \frac{\partial^2 w}{\partial z^2}.$$

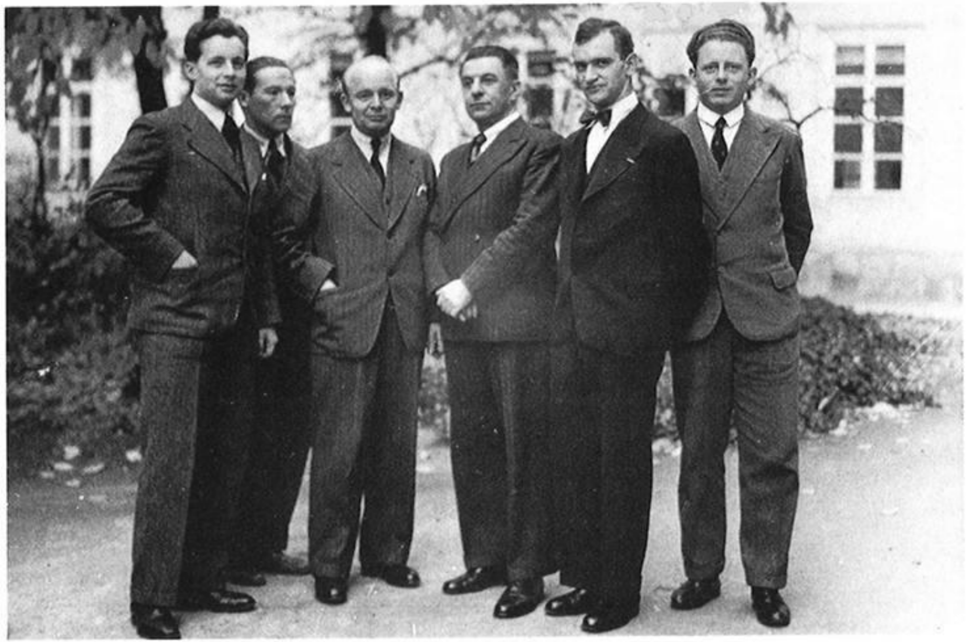
$$\frac{\partial p}{\partial t} + \frac{\partial w}{\partial t} = 0.^{8}$$

$$\frac{\partial w}{\partial t} = \frac{k}{\nu\gamma} \frac{\partial^2 w}{\partial z^2} = c \frac{\partial^2 w}{\partial z^2}.^{10}$$

Terzaghi's one-dimensional consolidation theory, 1936

Personalities: Karl von Terzaghi Professor at Vienna Technical University 1929-1938

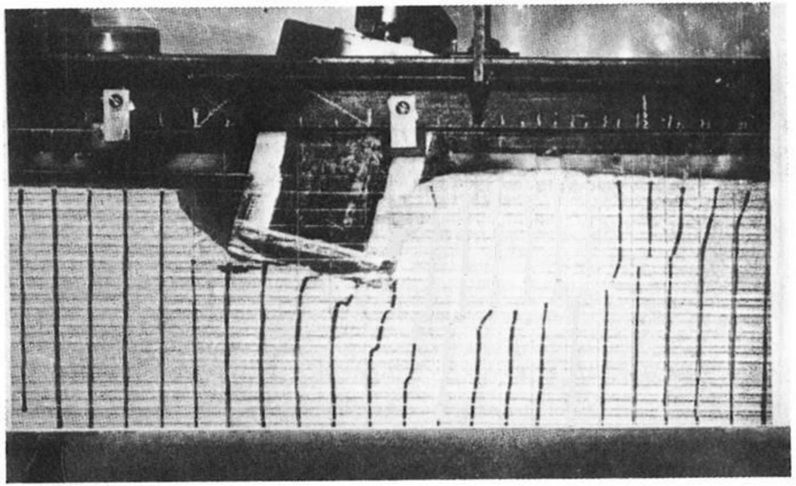
Otto K. Fröhlich: Professor at Vienna Technical University 1940-1956
Hubert Borowicka: Professor at Vienna Technical University 1957-1980



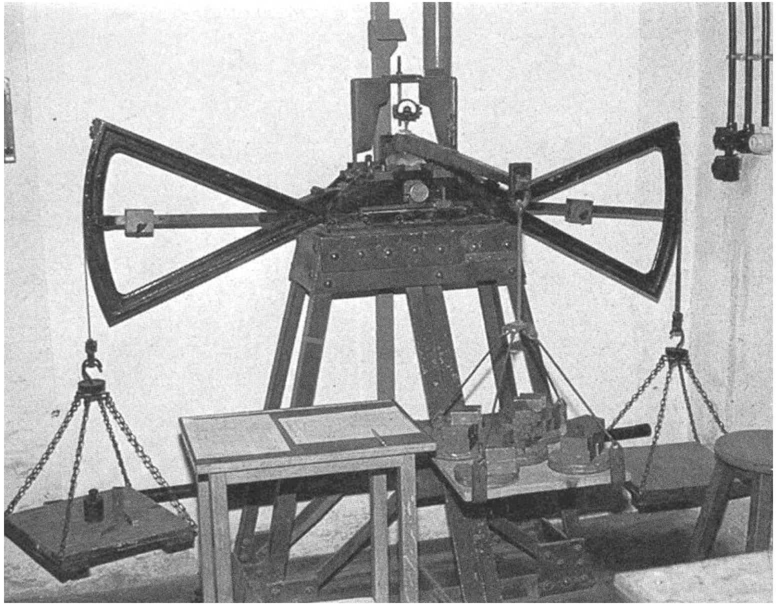
Co-workers of K.v.Terzaghi in Vienna, 1935
K. Kienzl, O. Schwarz, J. Hvorslev, O.K. Fröhlich,
H. Borowicka, W. Steinbrenner

Personalities: Karl von Terzaghi Professor at Vienna Technical University 1929-1938

Otto K. Fröhlich: Professor at Vienna Technical University 1940-1956
Hubert Borowicka: Professor at Vienna Technical University 1957-1980

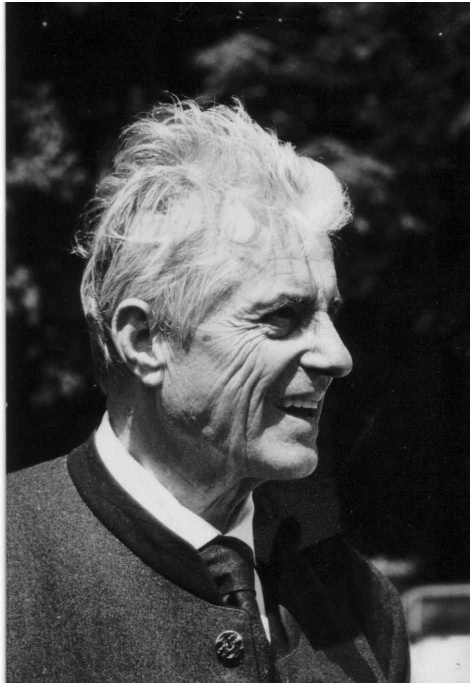


Laboratory experiment of bearing capacity of footings under inclined loading
A.R. Jumikis and O.K. Fröhlich



Shear box test apparatus
“Vienna routine shear test”
(After Hubert Borowicka)

Personalities: Christian Veder Professor at Graz University of Technology 1964-1978



Christian Veder 1907-1984

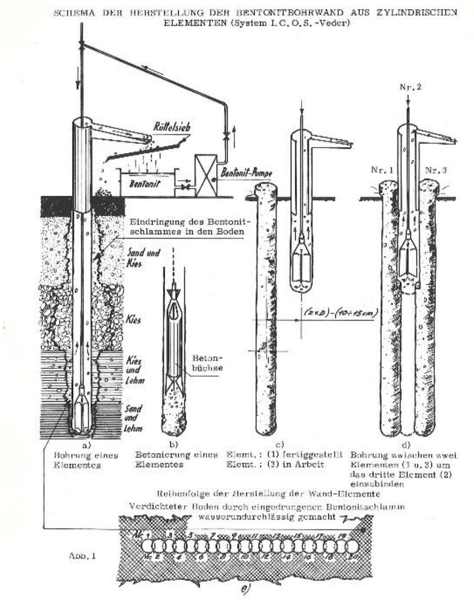
Christian Veder and Karl v. Terzaghi

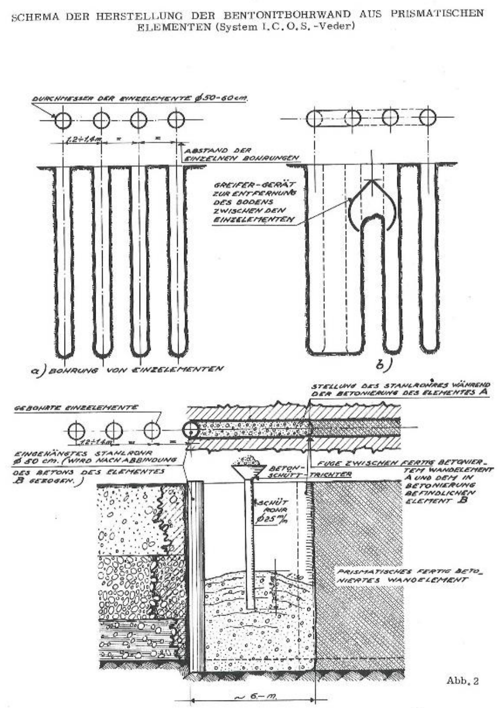
https://de.wikipedia.org/wiki/Christian_Veder

Time Capsule Project (TCP)

Personalities: Christian Veder Professor at Graz University of Technology 1964-1978

Inventor of diaphragm wall technique





Source:
Ch. Veder: *Neue Verfahren zur Herstellung von untertägigen Wänden und Injektionsschirmen in Lockergesteinen und durchlässigem Fels*
Mitteilungen des Institutes für Wasserwirtschaft, Grundbau und Konstruktiven Wasserbau der Technischen Hochschule Graz, 1959

Personalities: Christian Veder Professor at Graz University of Technology 1964-1978

Inventor of diaphragm wall technique

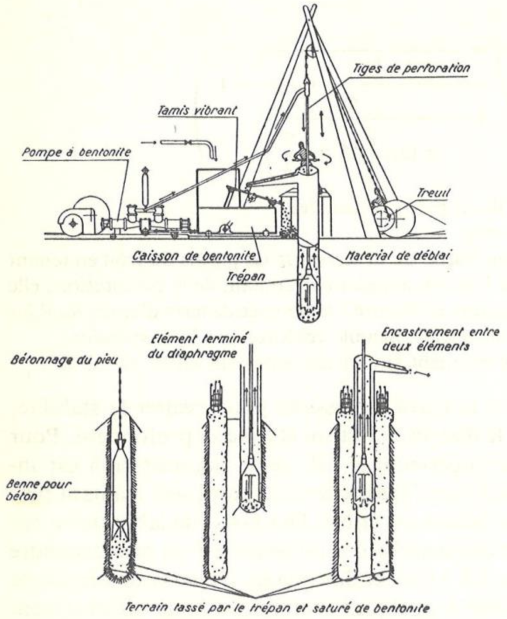


Fig. 1 Schéma d'exécution du diaphragme imperméable
Construction of the Impervious Diaphragm

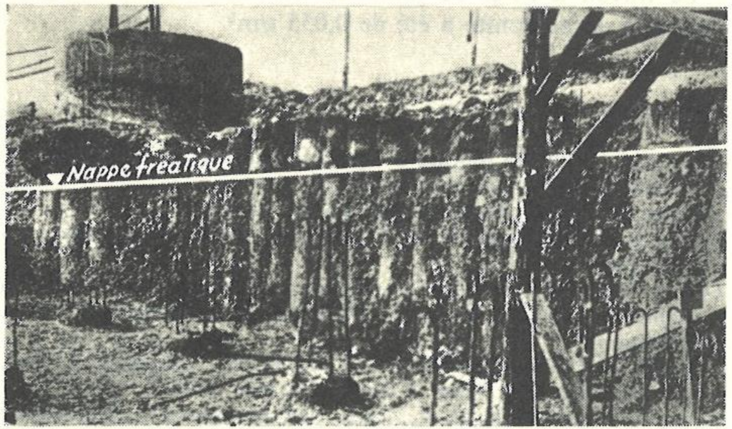


Fig. 3 Vue du diaphragme en béton partiellement découvert – Chantier de Volturno
Concrete Diaphragm Partly Uncovered on the Volturno Building Site

Specialist contractor I.C.O.S., Milano, Italy: first applications of diaphragm walls in late 1940s

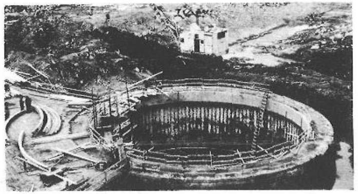
Source:
Ch. Veder: *Method for the Construction of Impermeable Diaphragms at Great Depths by Means of Thixotropic Muds*
Proceedings III ICSMFE, Zürich, Vol. II, 91-94

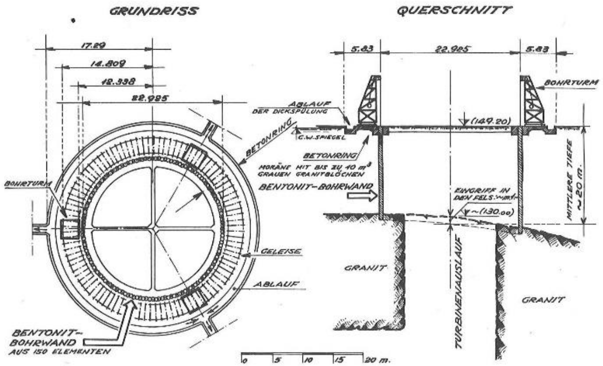
Personalities: Christian Veder Professor at Graz University of Technology 1964-1978

In-situ test on bored pile wall constructed with bentonite slurry support, Gorica, 1951

Source:
Ch. Veder: *Die Schlitzwandbauweise – Entwicklung, Gegenwart und Zukunft*
Österreichische Ingenieur-Zeitschrift, 1975, Heft 8, 247-257

Example Circular Shaft

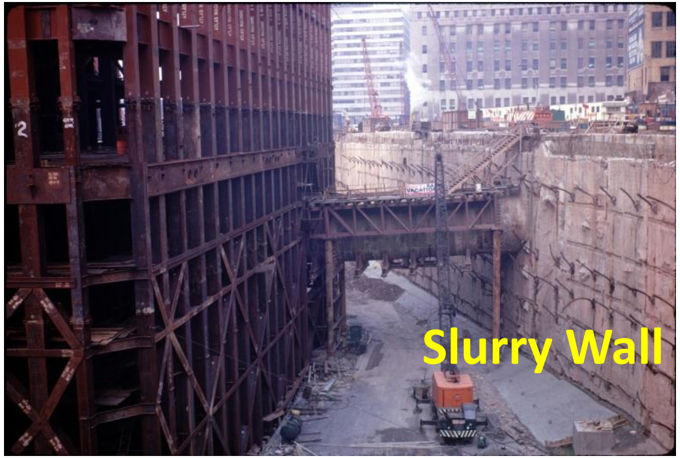




Source:
Ch. Veder: *Neue Verfahren zur Herstellung von untertägigen Wänden und Injektionsschirmen in Lockergesteinen und durchlässigem Fels*
Mitteilungen des Institutes für Wasserwirtschaft, Grundbau und Konstruktiven Wasserbau der Technischen Hochschule Graz, 1959

Personalities: Christian Veder Professor at Graz University of Technology 1964-1978

- 1,000 m long, 900 mm thick
- 158 panels, each ~ 6.7 m wide
- installed in 12 months (1967/68)



Personalities: Christian Veder Professor at Graz University of Technology 1964-1978

Suggestion for stabilising Leaning Tower of Pisa

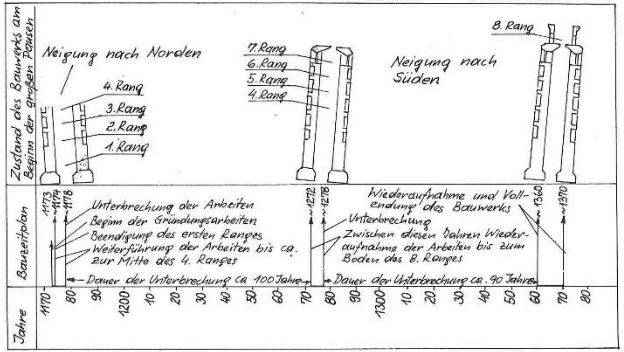


Abb. 1 Bauphasen des Turmes von Pisa (Ricerche e studi, 1971)
Stages of construction of the Tower of Pisa.

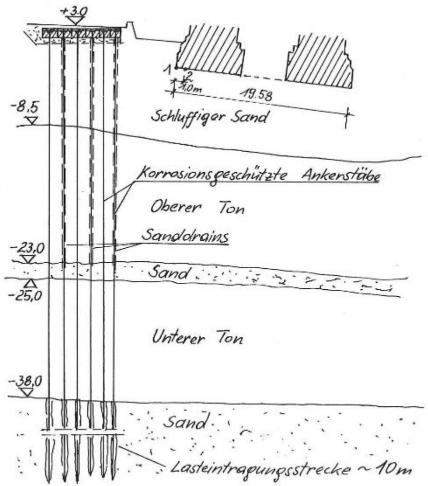


Abb. 4 N - S Schnitt
N - S section

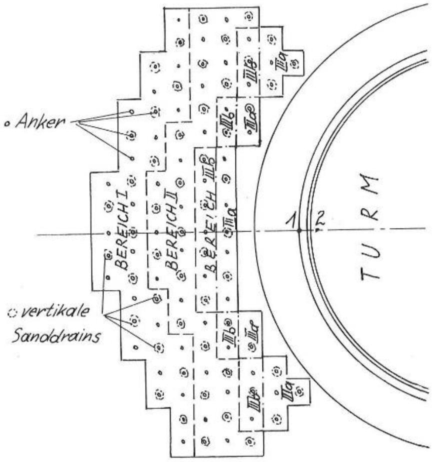


Abb. 2 Unterteilung des Ankerfeldes
Subdivision of the anchorage-field

nicht kleiner bzw. die maximale Kantenpressung nicht größer wird. Die Lastaufbringung erfolgt in Stufen von 0,5 bar, das entspricht etwa einer Ankerkraft von je 8,4 t. Für jede dieser

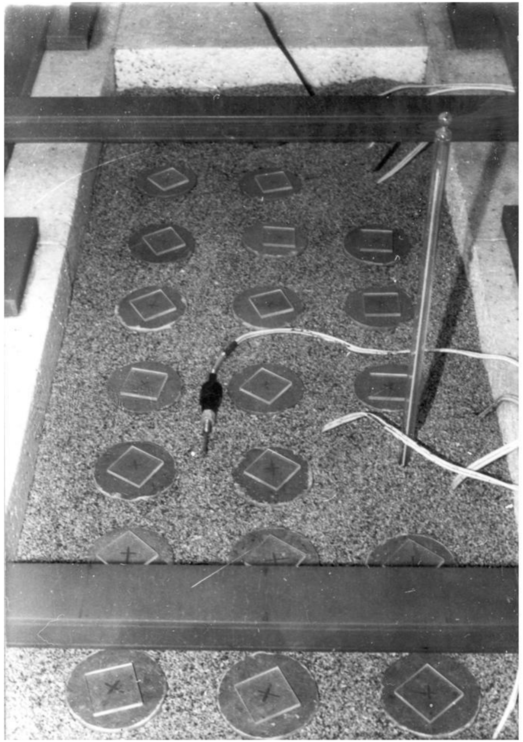
Source:
Ch. Veder: *Der schiefe Turm von Pisa. Bodenmechanische Probleme meines Sanierungsvorschlages*
Technische Universität Wien - Mitteilungen für Grundbau, Bodenmechanik und Felsbau (1976)

Personalities: Heinz Brandl Professor at TU Wien 1981-2008

- ISSMGE Vice-President for Europe 1997-2001
- President of Austrian Geotechnical Society 1972-2015
- Rankine Lecturer 2002
- Member of Royal Academy of Sciences of Belgium
- Member of New York Academy of Sciences
- Medal of Merit for Macedonia

https://de.wikipedia.org/wiki/Heinz_Brandl

Laboratory experiments to investigate the effects of freezing-thawing cycles on the behaviour of lime and cement stabilized fine grained soils



Source:
H. Brandl: Der Einfluss des Frostes auf kalk- und zementstabilisierte feinkörnige Böden. Mitteilungen des Institutes für Grundbau und Bodenmechanik; Technische Hochschule (nunmehr Technische Universität) Wien, Heft 8, 1967

Personalities: Heinz Brandl Professor at TU Wien 1981-2008

Innovative solutions for foundations of motorways in alpine regions in late 1970s (Tauernautobahn, Austria)

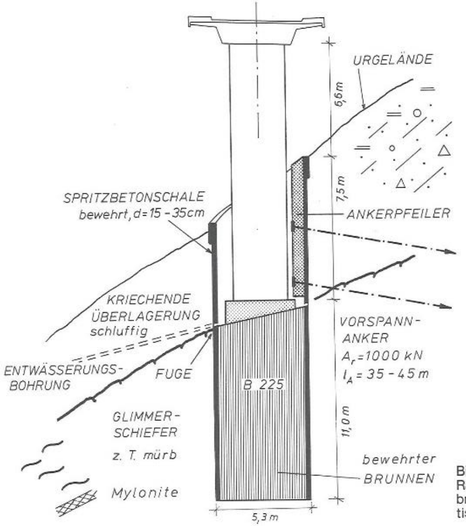


Bild 19:
Rampenbrücke L 22/1 (Betriebsumkehr Krems-brücke): »Knopflochlösung« mit Ankerrippe in elliptischem Spritzbetonschacht – Querschnitt

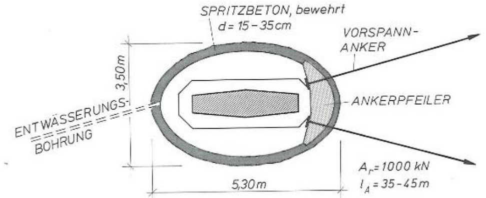
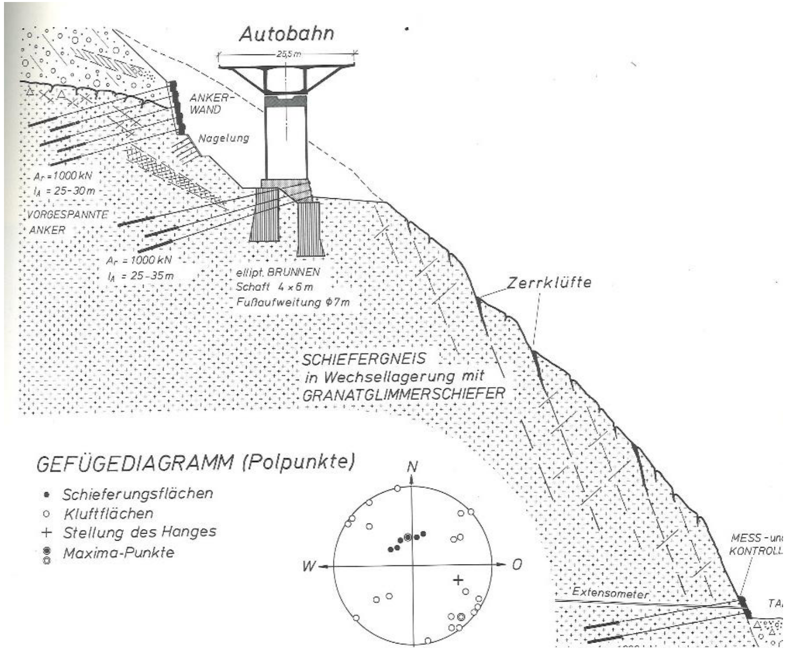


Bild 20:
Grundriß zu Bild 19



Source:
H. Brandl and H. Brandecker – *Autobahnbau unter extremen geotechnischen Bedingungen*
Technische Universität Wien - Mitteilungen für Grundbau, Bodenmechanik und Felsbau (1982)

Personalities: Heinz Brandl Professor at TU Wien 1981-2008

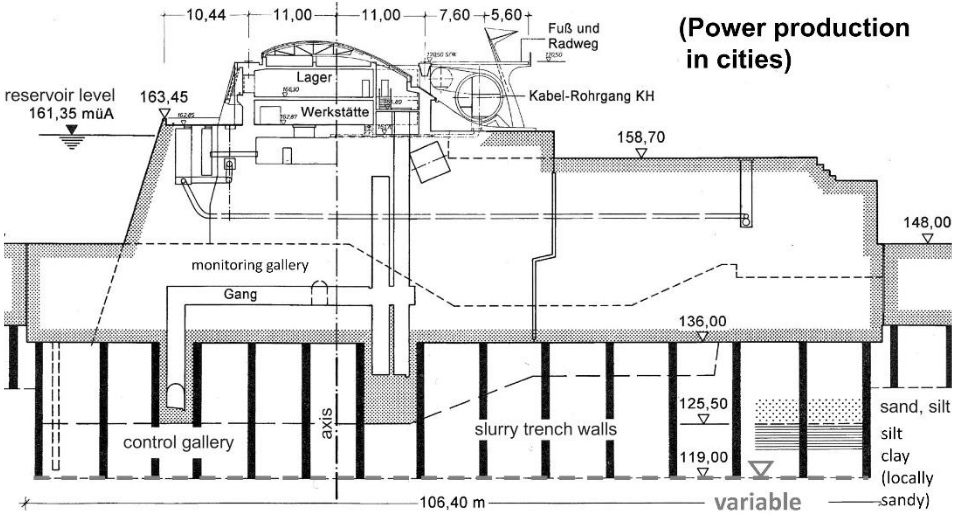
Innovative solutions for foundations and slope stabilization of motorways in Austria

Source:
H. Brandl: Probleme des Erd- und Grundbaues bei der Tauernautobahn-Scheitelstecke.
Eigenverlag der Tauernautobahn AG, Salzburg, 1976

Source:
H. Brandl: Bridges, embankments and retaining structures in unstable slopes.
Keynote Paper. Conference „Contemporary Civil Engineering Practice 2012“. Faculty of Technical Sciences, University of Novi Sad and Society of Civil Engineers of Novi Sad, Serbia. 17-18 May, 2012. Proceedings, pp. 23 – 46.

Personalities: Heinz Brandl Professor at TU Wien 1981-2008

Geotechnical Challenges at construction of power station Freudenau



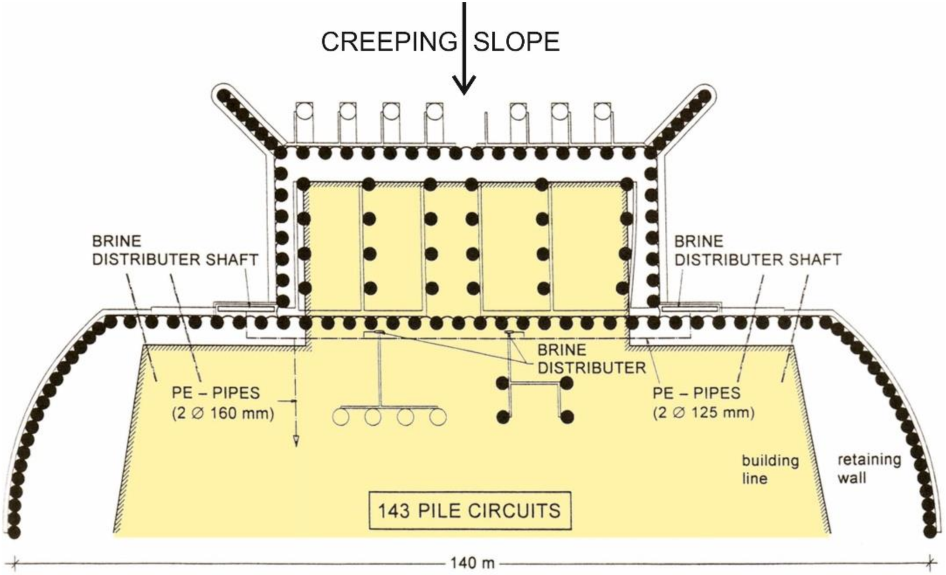
Source:
H. Brandl: Bodenmechanische und erdstatische Fragestellungen beim Bau des Kraftwerkes Freudenau. Felsbau 15, Nr. 4. 1997

Personalities: Heinz Brandl Professor at TU Wien 1981-2008

Reinforcement of 60 m high embankments (Egnatia Odos Highway, Greece)

Source:
H. Brandl: Geosynthetics applications for the mitigation of natural disasters and for environmental protection. Keynote Paper (extended "Giroud-Lecture" of IGS-World Conference in Brazil 2010) Geosynthetics International 2011, 18, No. 6 (Dec. 2011), pp. 340-390.

Innovative systems for energy foundations (Bad Schallerbach, Austria)



Source:
H. Brandl: Energy foundations for cooling and heating buildings (Innovative systems combining aspects of construction, energy and environmental protection). 25th Anniversary of the Austro-Arab Chamber of Commerce (AACC) Vienna, 22 May, 2014

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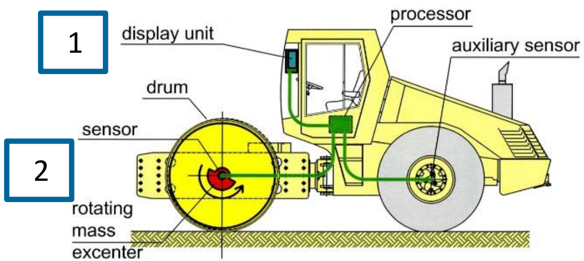
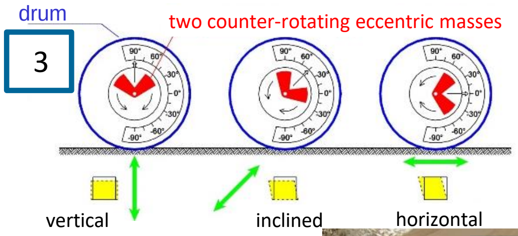
PAST

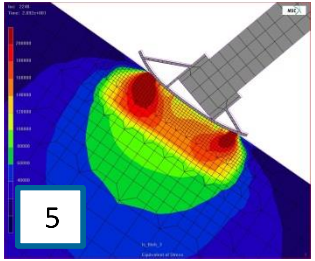
FUTURE

Research TU Wien: Soil Dynamics and Dynamic Compaction Methods

1. Continuous Compaction Control (CCC) with vibratory rollers
2. CCC for various types of excitation
3. Control criteria and compaction optimization for feedback controlled rollers
4. Compaction effect of dynamically excited polygonal drums
5. Equipment optimization for vibratory plates and roof compactors
6. Compaction effect and documentation of Rapid Impact Compaction
7. Integrated compaction control for dynamic compaction
8. Dynamic load plate test with the falling weight deflectometer and calibration of the dynamic load plate



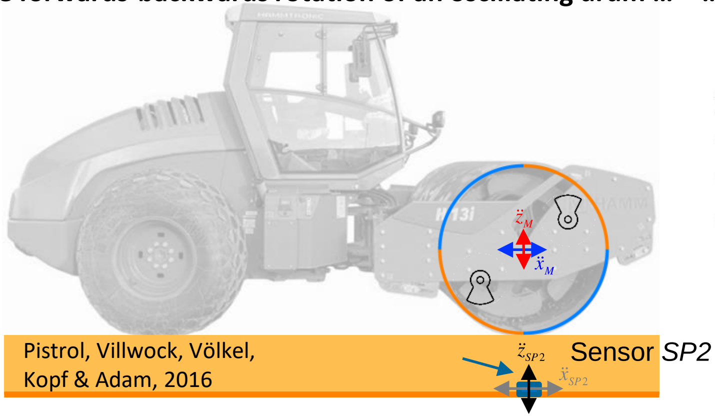


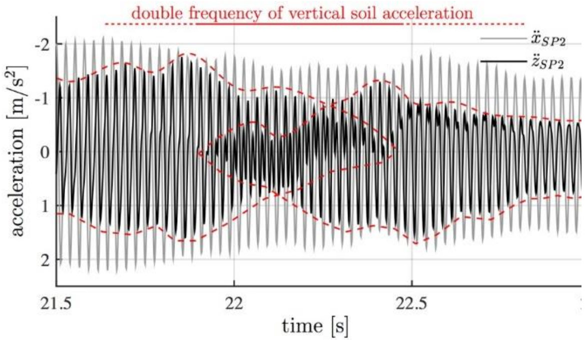


Adam, Kopf, Pistrol, Nagy, Barbir & Hager, 2016

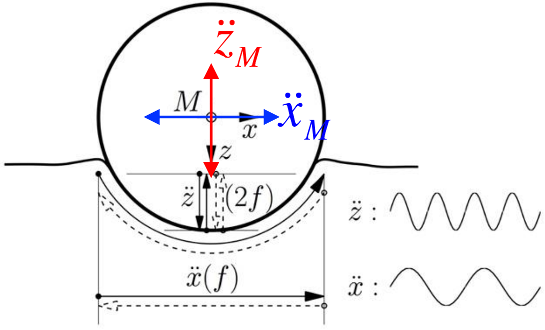
Research TU Wien: Development of an IC System for Oscillation Rollers

The forwards-backwards rotation of an oscillating drum … … causes a characteristic behaviour of soil accelerations … … due to the settlement trough.

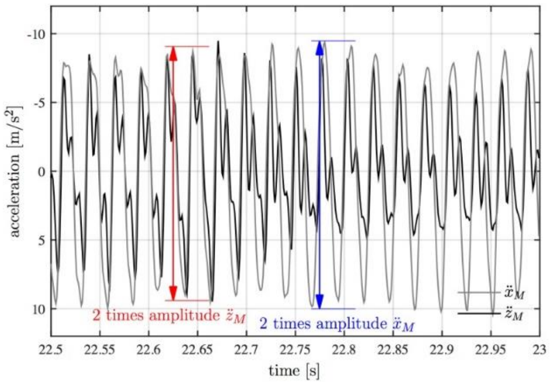


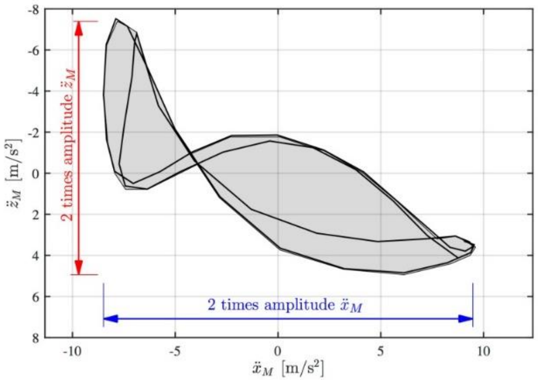


Soil accelerations measured by Sensor *SP2*

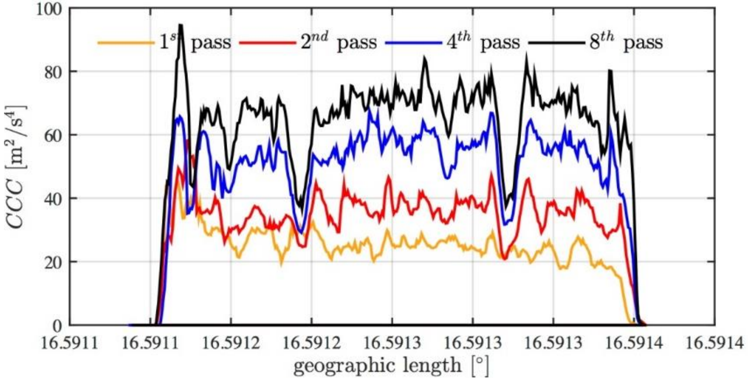


The characteristics replicate the bearing of the drum (point *M*) …





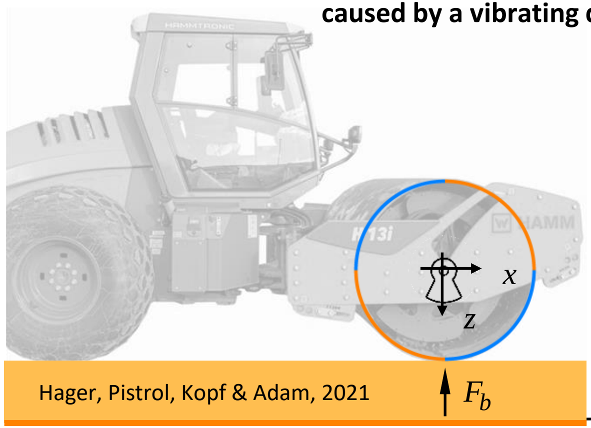
… and are used in an algorithm to calculate the first functional ICMV (CCC value) for oscillation rollers:



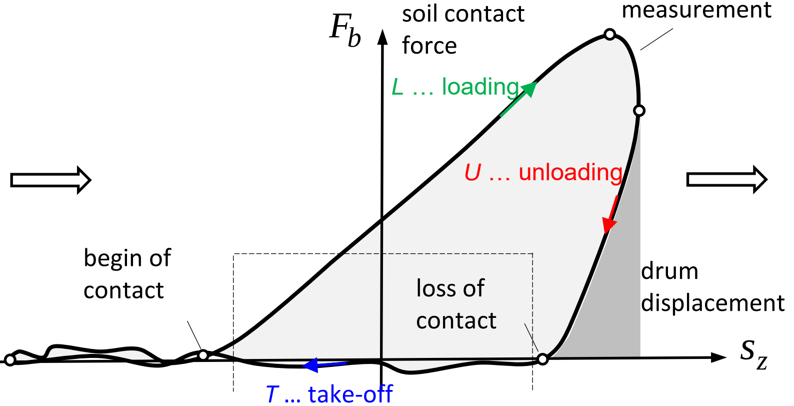
Time Capsule Project (TCP)

Research TU Wien: Development of a novel ICMV for Vibratory Rollers

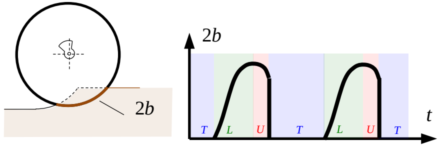
The mainly vertical loading of the subgrade caused by a vibrating drum …



… results in a measured soil response (force-displacement diagram):

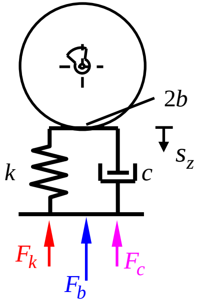


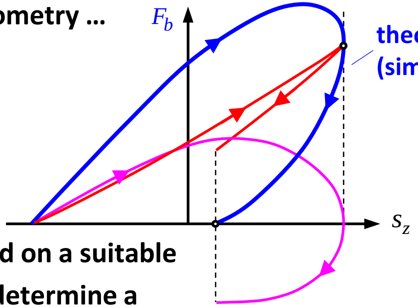
The measured motion behavior of the drum gets applied to a simplified model …



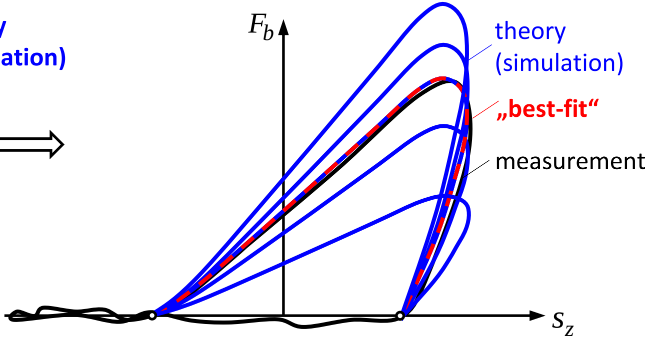
… to determine the contact geometry between the drum and the subgrade:

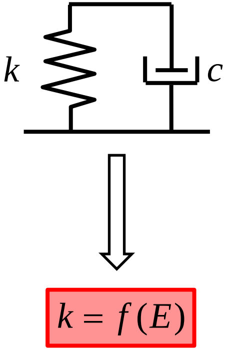
The measured motion behavior with the corresponding contact geometry …





… gets imposed on a suitable soil model to determine a theoretical system response.





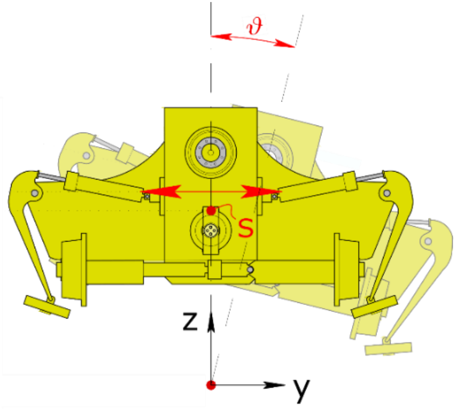
Research TU Wien: Ballast Compaction with the Dynamic Track Stabilizer

Operating direction

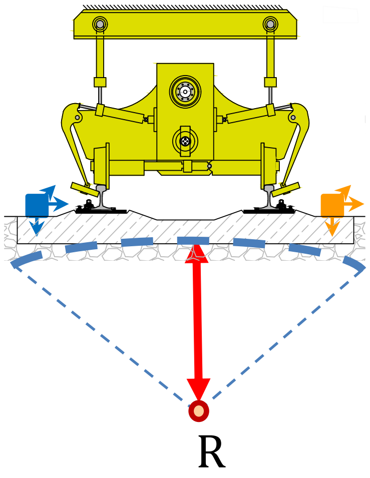
Alignment/Tamping

Dynamic Track Stabilizer

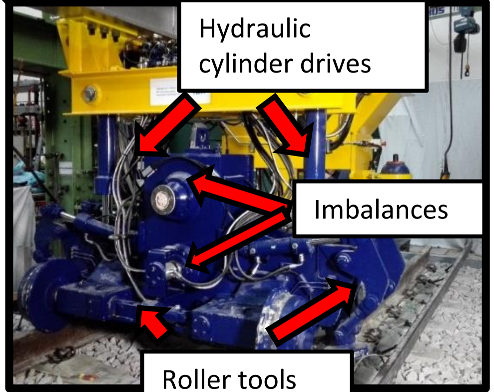
The design of the DTS causes a rocking motion …



Barbir, Pistrol, Kopf, Adam, Auer & Antony, 2019



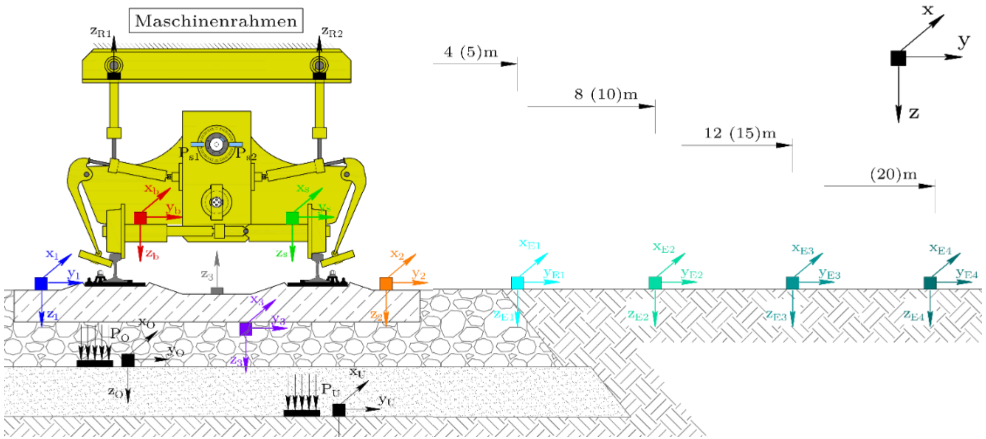
… which can also be observed on the sleepers.



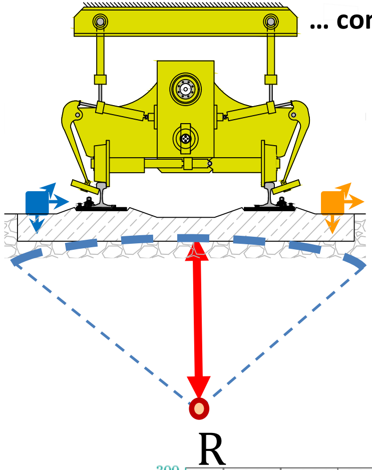
Components of the DTS

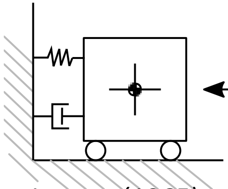
Research TU Wien: Modelling the Machine-Soil Interaction

A unique measurement setup …

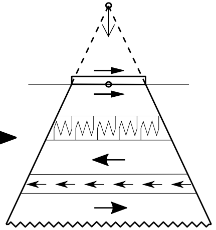


… combined with simplified kinematics …



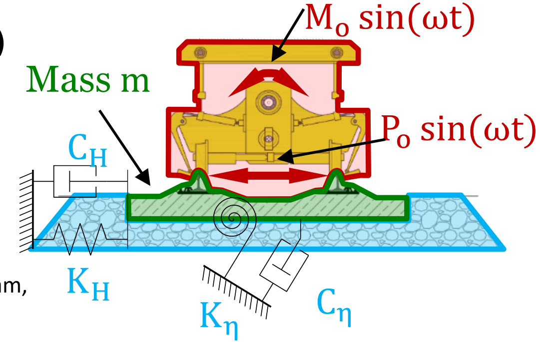


Lysmer (1965) and *Hall (1967)*



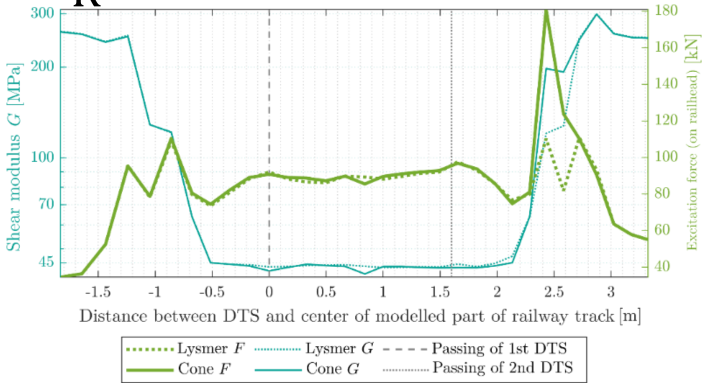
Wolf (1994)

… lead to a (verified) simple mechanical model …



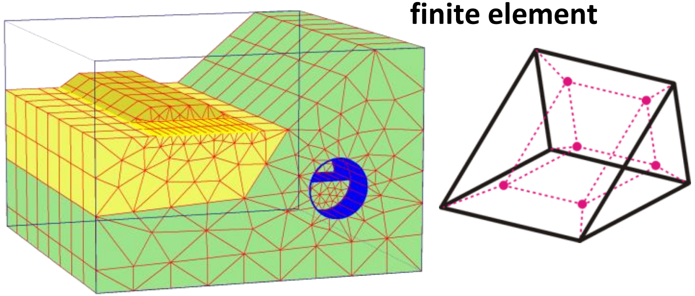
Dafert, Pistrol, Kopf & Adam, ongoing research

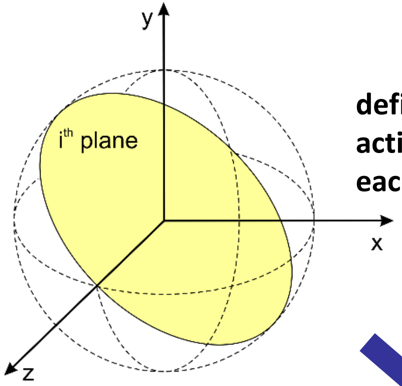
… which allows for the back-calculation of soil parameters (like shear-modulus G):



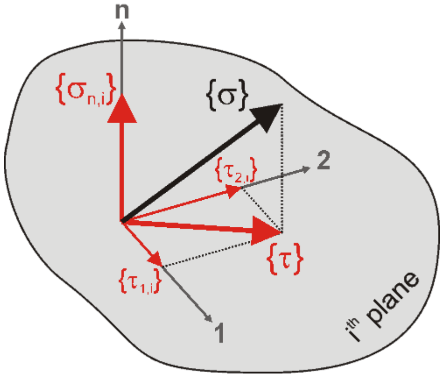
Research Graz University of Technology: Multilaminate Model for Soils

Basic Formulation

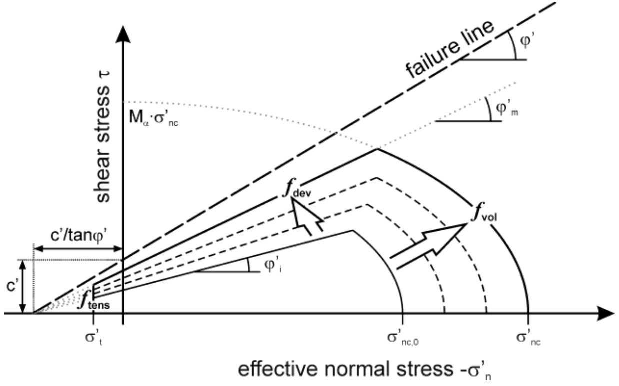




definition of n independently acting integration planes in each stress point



calculation of local stress components from global stress state



formulation of constitutive relations on integration planes

$$d\varepsilon = \sum_{i=1}^{n} T_i \cdot d\varepsilon_i \cdot w_i$$

weighted summation over all integration planes
> global behaviour

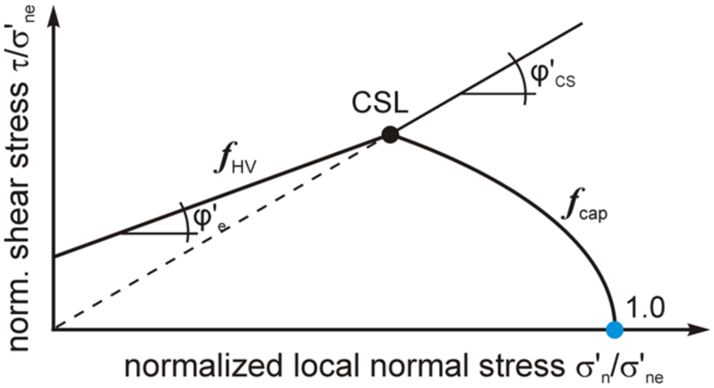
Schweiger, Wiltafsky, Scharinger & Galavi, 2009

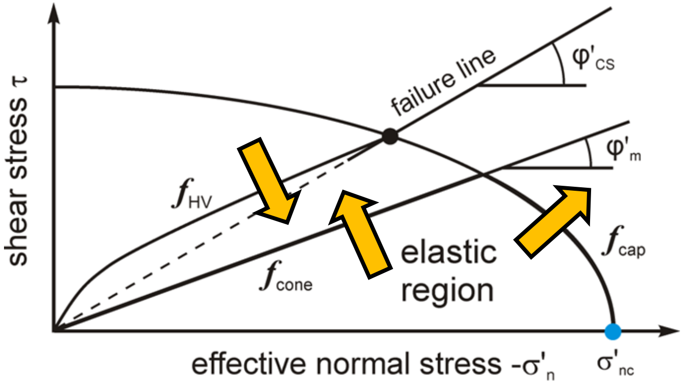
Research Graz University of Technology: Multilaminate Model for Soils

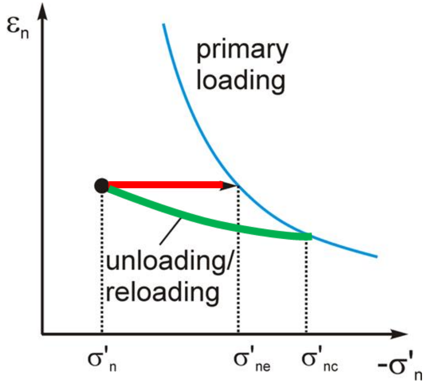
Enhancement

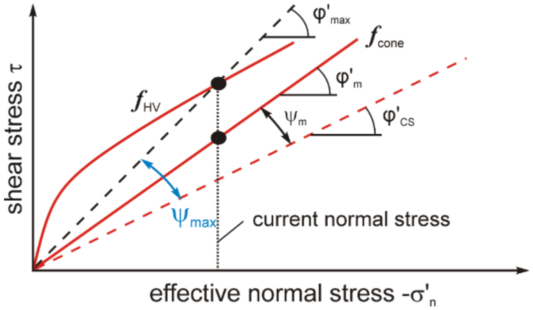
Hsorslev-Surface for OC-Soils

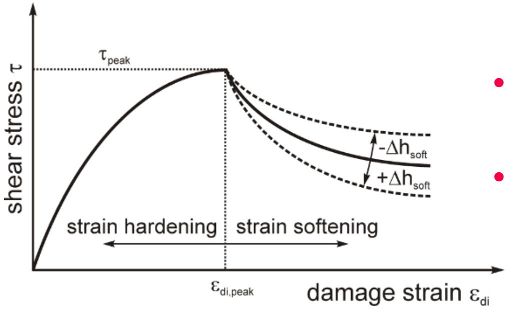
- **Local stresses τ, σ'_n and local normal strains ε_n**









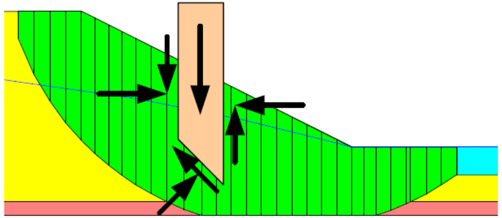


- Plastic normal strains reduce pre-consolidation pressure σ'_{nc}
- Softening parameter h_{soft} governs rate of strain softening

Schädlich & Schweiger, 2014

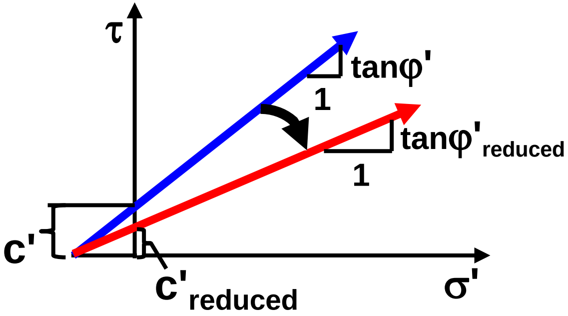
Research Graz University of Technology: Slope Stability Analysis [FELA / SRFEA]

Limit Equilibrium Analysis



- Overall form of the failure surface needs to be determined in advance
- Distribution of the interslice forces is assumed differently in various methods
- Kinematic admissibility is not ensured
- Need to perform a global search for identifying the failure mechanism with the lowest factor of safety

Strength Reduction Finite Element Analysis



$$FoS = \frac{c'}{c'_{reduced}} = \frac{\tan\varphi'}{\tan\varphi'_{reduced}}$$

Tschuchnigg, Schweiger & Sloan, 2015

Finite Element Limit Analysis (FELA)

Lower bound

- Requires a stress field that satisfies the boundary conditions, the yield criterion and fulfils equilibrium.
- Any loads supported by such a stress field are a lower bound on the true failure load.

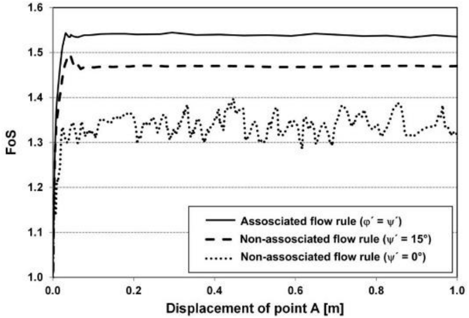
Upper bound

- Is based on a velocity field that satisfies the boundary conditions and implies an associated flow rule (strain and velocity compatibility conditions).
- Internal work (due to plastic shearing) is equated to the external work (minimum internal power dissipation).
- Any loads derived from such a velocity field are an upper bound on the true failure load.

Time Capsule Project (TCP)

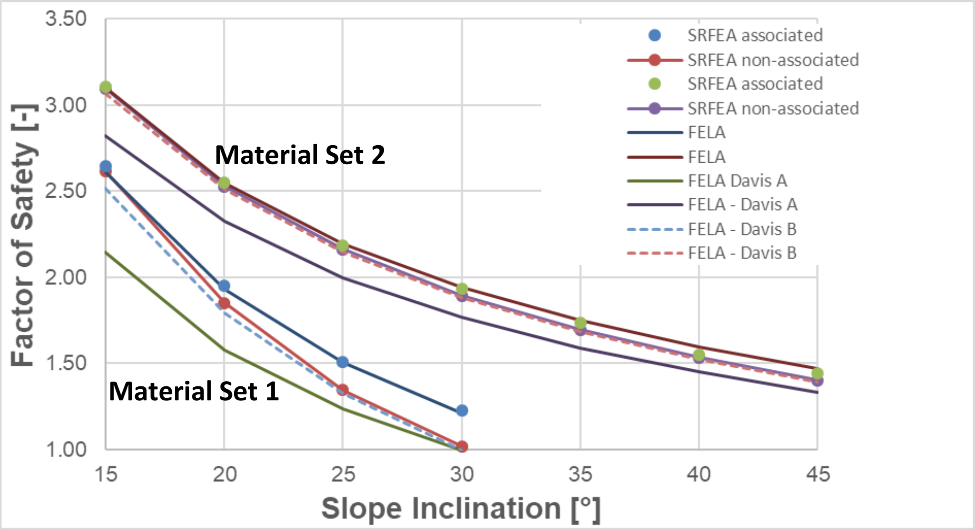
Research Graz University of Technology: Slope Stability Analysis [FELA / SRFEA]

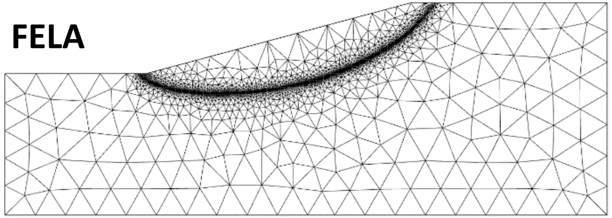
- **Disadvantage FELA**: implies associated plasticity
- **Disadvantage SRFEA**: non-associated plasticity may lead to numerical instabilities

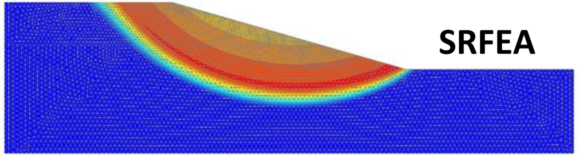


Possible solution: Modified "Davis-Approach"

Example:







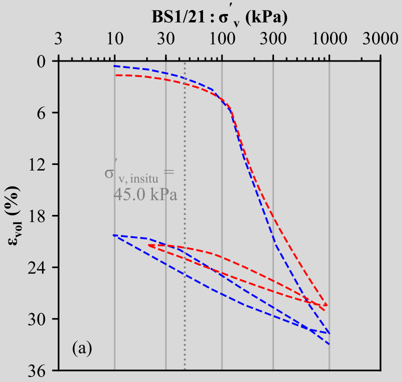
Tschuchnigg, Schweiger & Sloan, 2015

Research Graz University of Technology: Characterization of structured sediments

Parameter identification by means of in-situ & laboratory tests

Aim: Improved characterization of **stress-strain behavior** in postglacial sediments using **CPTu & SDMT**

Basis: Test sites



Post glacial sediments: Fussach, Salzburg & Seekirchen

Young sediments: Water reservoir Raggal

(1) Execution of **CPTu & (Medusa) SDMT**

(2) Soil sampling (e.g. block sampling) for laboratory testing

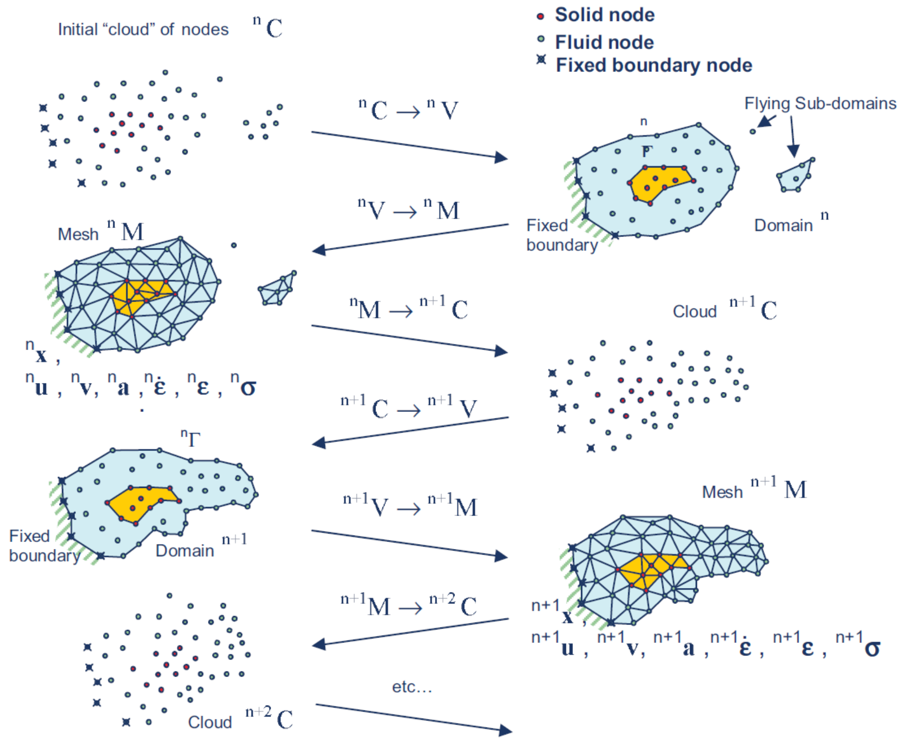
(3) Comprehensive **laboratory investigations** on undisturbed & reconstituted soil samples (e.g. bender element)

Interpretation:

Development of new **correlations** for CPTu & SDMT, calibrated based on laboratory results & monitoring data

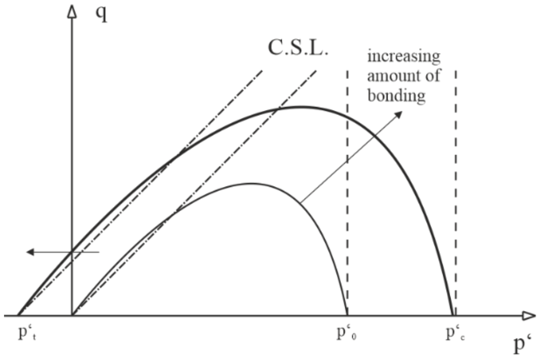
Research Graz University of Technology: Numerical Modelling of CPT

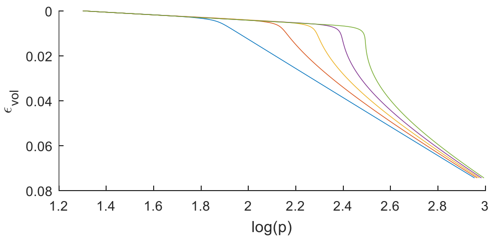
Particle Finite Element Method

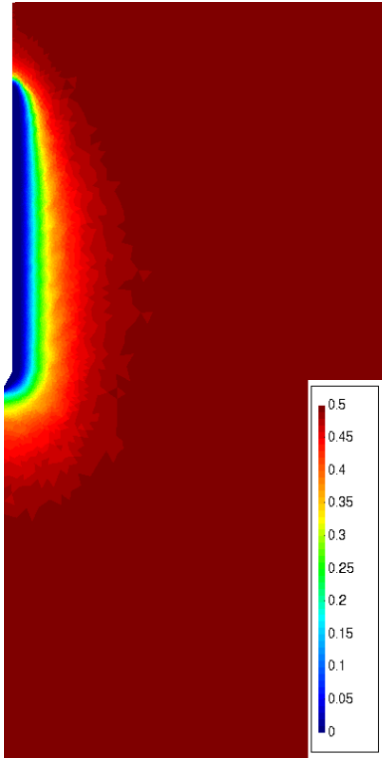


Hauser & Schweiger, 2021

Constitutive Model: CASM including destructuration





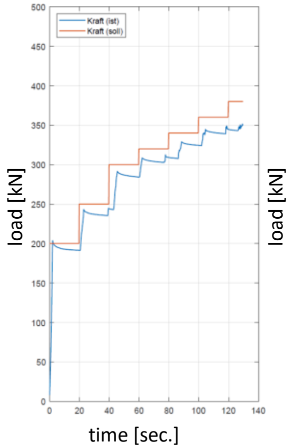


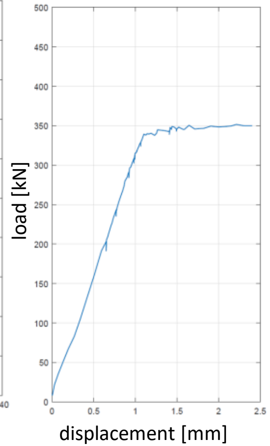
Example: Zone of destructuration during penetration

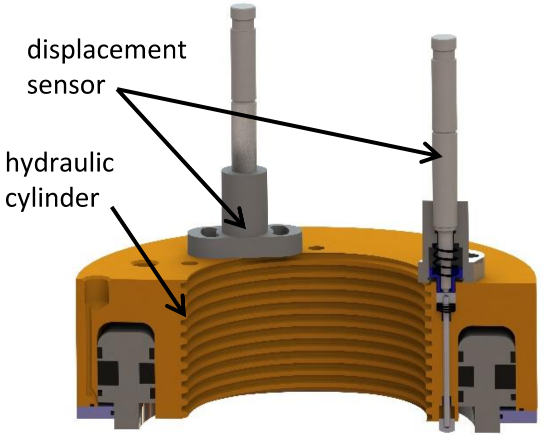
Research Graz University of Technology: Anchor lock-off-testing

Anchor lock-off-testing

- Determination of the lock-off-load
- Smaller and smarter equipment for anchor testing
- Changes in lock-off-load or behaviour of the anchor during the test give a feedback on damages or damage symptoms

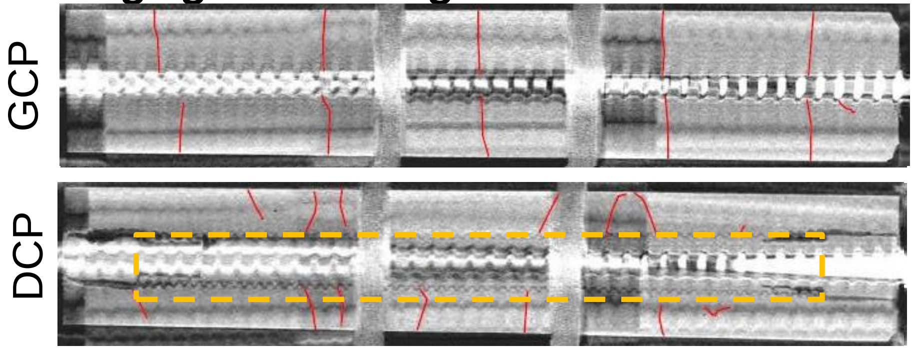




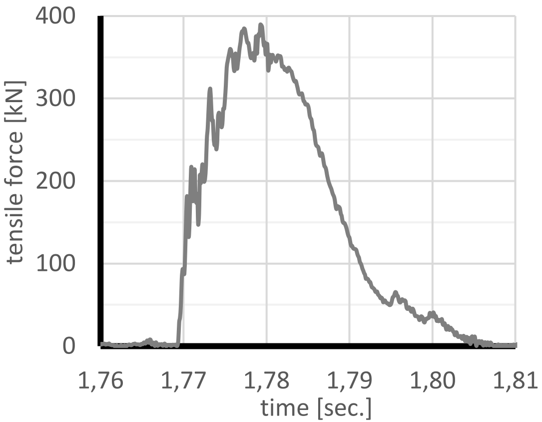


Research Graz University of Technology: Durability of micro-piles

CT-Imaging of cracked grout bodies



Dynamic testing of micro-piles



Durability of micro-piles for natural hazard protection

CT-imaging

- Grout cover protection (GCP) as a main corrosion protection system
- Corrosion of the (metal) tensile element due to a cracked grout body
- Crack width and distribution unknown
- Cracking behaviour influenced by corrosion protection systems (e.g. double corrosion protection DCP)

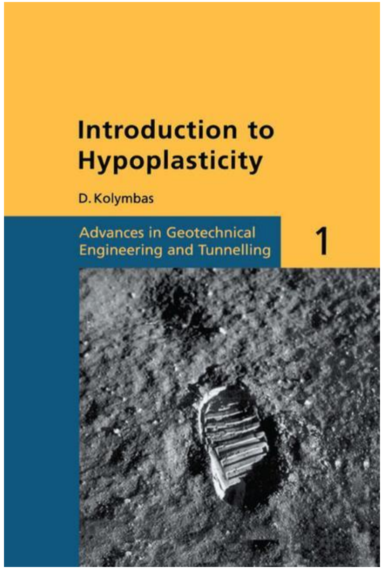
Dynamic loading vs. static loading

- Dynamic impacts due to natural hazard protection (e.g. rockfall)
- Static testing complex, cost-intensive and not corresponding to realistic loading effects (e.g. dynamic impact)

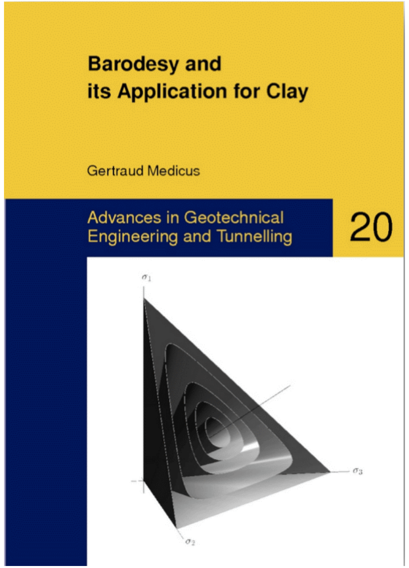
Research University of Innsbruck: Constitutive Modelling

Developing of alternative constitutive models for soils, i.e. models without yield surface and no splitting of strain in elastic and plastic part

Hypoplasticity



Barodesy

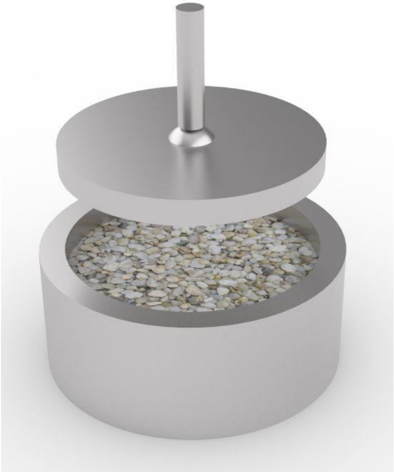


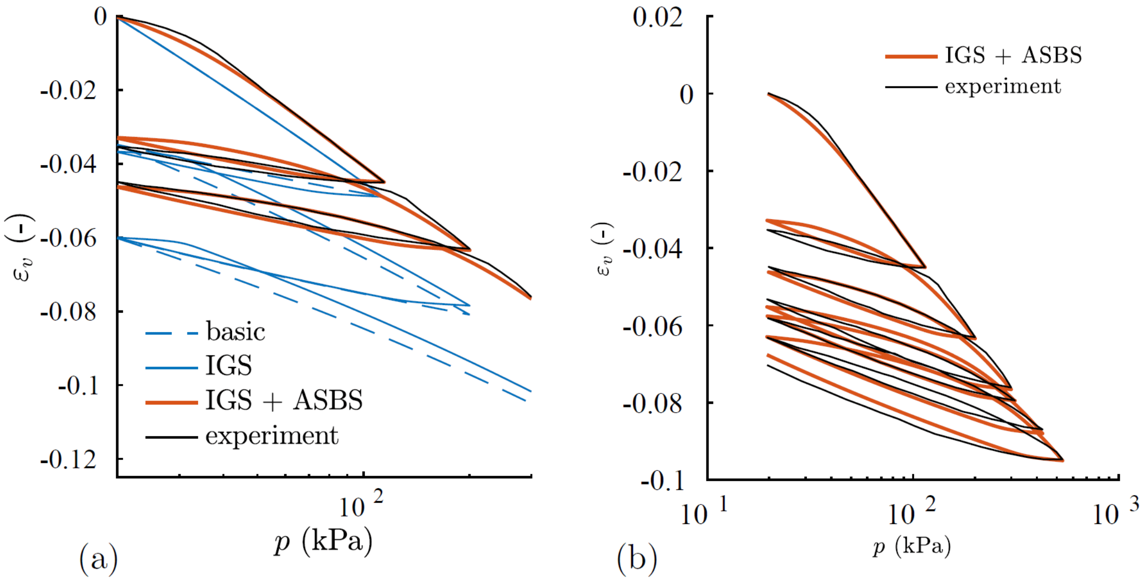
Originated in 1985 by D. Kolymbas in Karlsruhe with major contributions since 1997 in Innsbruck in numerical implementation by D. Roddemann, W. Fellin, A. Ostermann

Originated in 2009 by D. Kolymbas in Innsbruck with contributions of G. Medicus, W. Fellin, M. Bode, A. Ostermann

Research University of Innsbruck: Constitutive Modelling

Enhancing the numerical response to cyclic loading





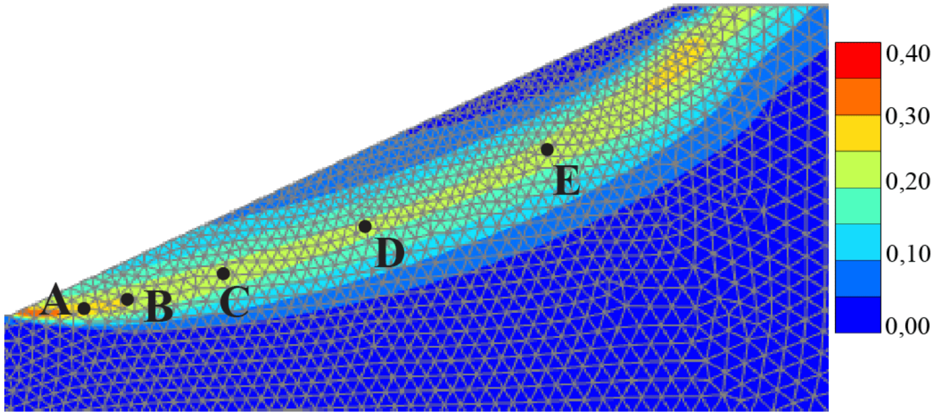
Cyclic oedometer test: Experiments on reconstituted Newfield clay by D. Namy (1970); IGS … intergranular strain concept by Niemunis & Herle (1997), ASBS … asymptotic boundary surface extension by M. Bode & W. Fellin & G. Medicus (2021)

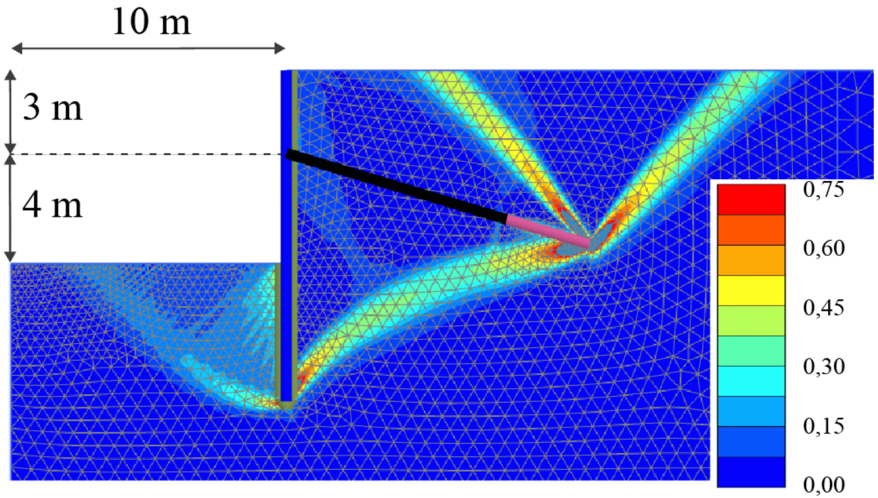
Austrian Science Fund: P 28934-N32
FWF Der Wissenschaftsfonds.

Research University of Innsbruck: Strength Reduction Techniques

Applying strength reduction to non-elasto-plastic models

(B. Schneider-Muntau & G. Medicus & W. Fellin, 2018)

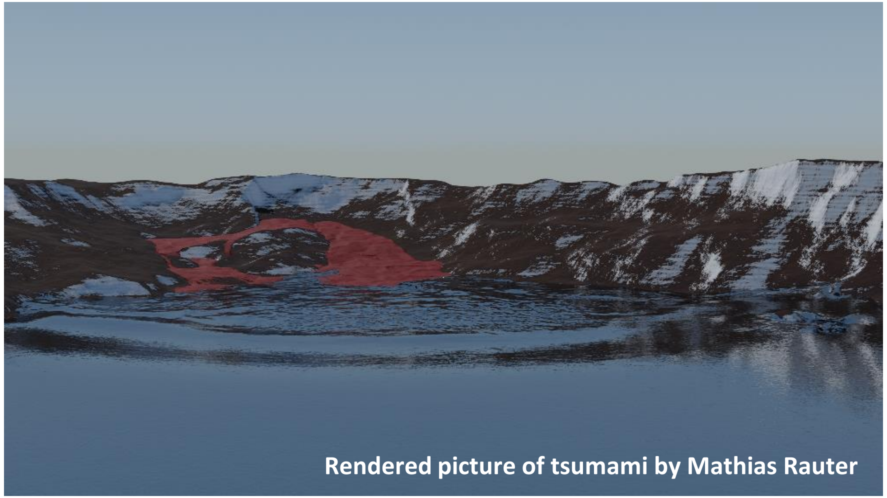




Shear zones at failure indicated by void ratio; Barodesy implemented in Plaxis
(M. Bode & G. Medicus & W. Fellin, 2020)

Research University of Innsbruck: Gravitational Massflow

Numerical Modelling of debris flow and snow avalanches



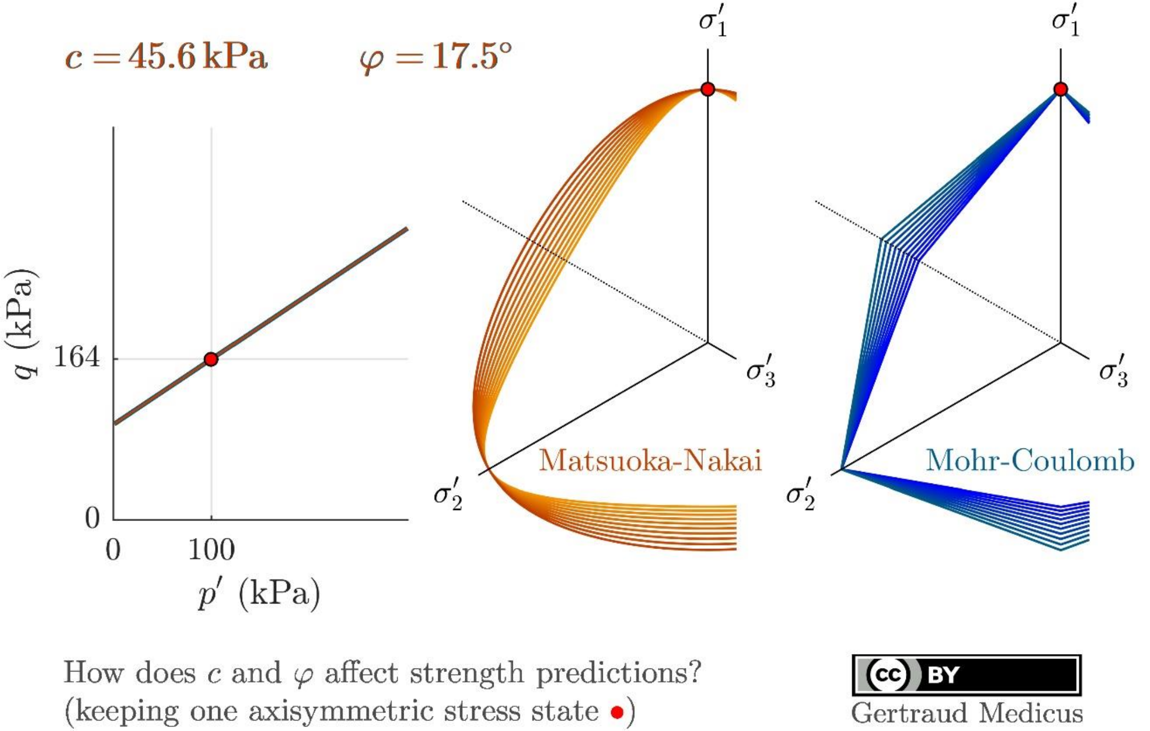
Video of simulation

Tsunami modelling of the 2014 Lake Askja flank collapse (Rauter et al., 2022)
computed on the High Performance Computing cluster at the University of Innsbruck

Research University of Innsbruck: Teaching and Learning Constitutive Models

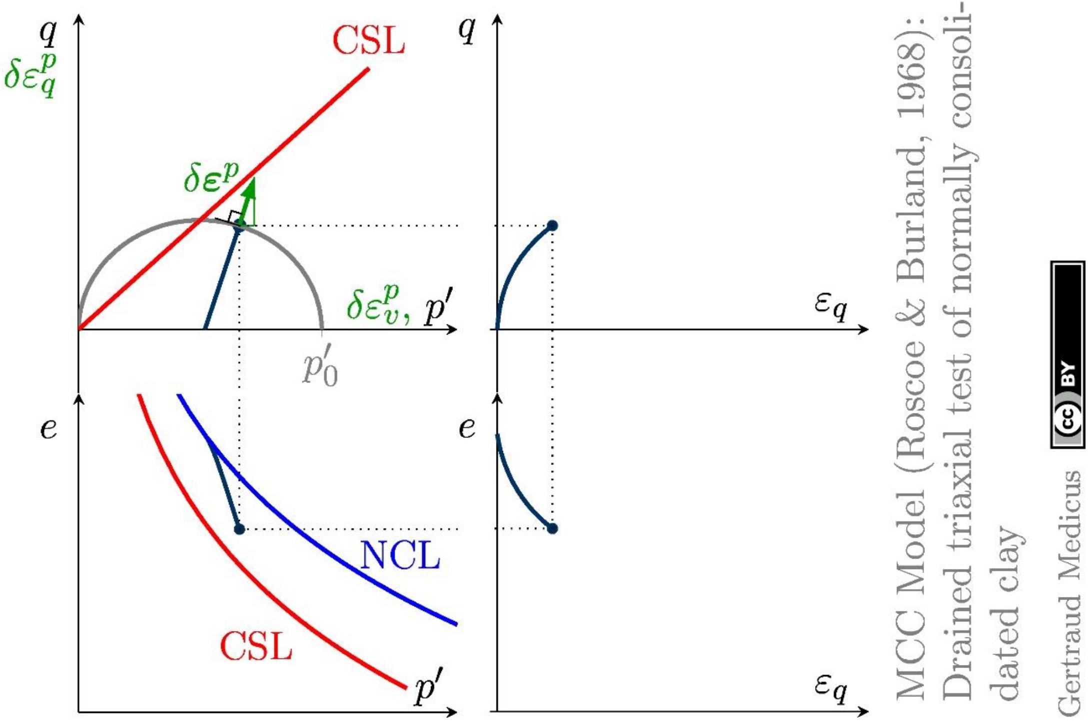
Open education project: https://soilmodels.com/soilanim/

Matsuoka-Nakai vs. Mohr-Coulomb: [click to start animation]



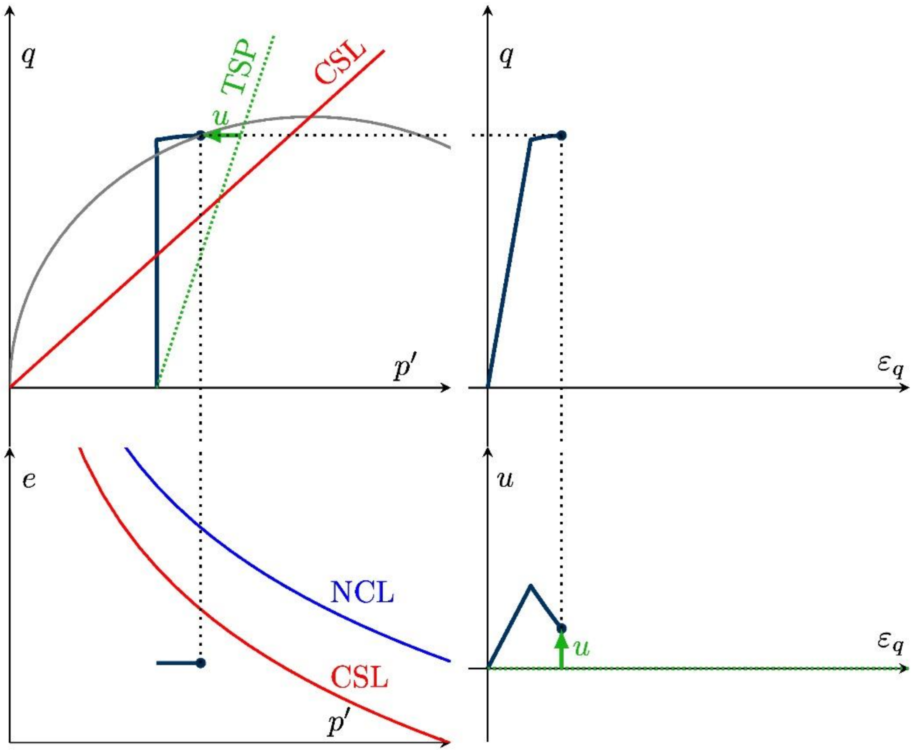
Modified Cam Clay Model: [click to start animation]

Conventional, drained triaxial test, normally consolidated



Modified Cam Clay Model: [click to start animation]

Conventional, undrained triaxial test, Highly overconsolidated

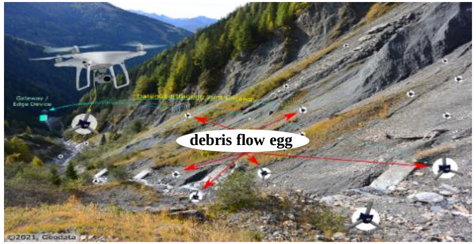


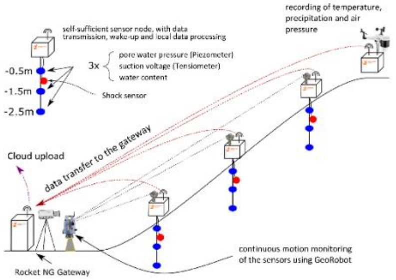
MCC Model (Roscoe & Burland, 1968): Undrained triaxial test of highly overconsolidated clay
Gertraud Medicus

Research University of Innsbruck: Natural Hazards and Geotechnical Engineering

HangmurenNet

- Measurement of relevant (hydro)geological parameters and characteristics of the slope debris flow
- Continuous measurement of possible trigger parameters on/in the slope debris flow

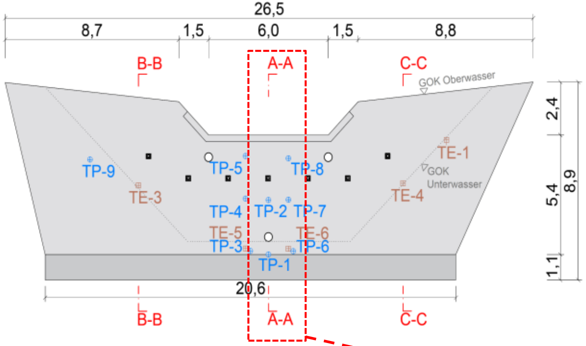


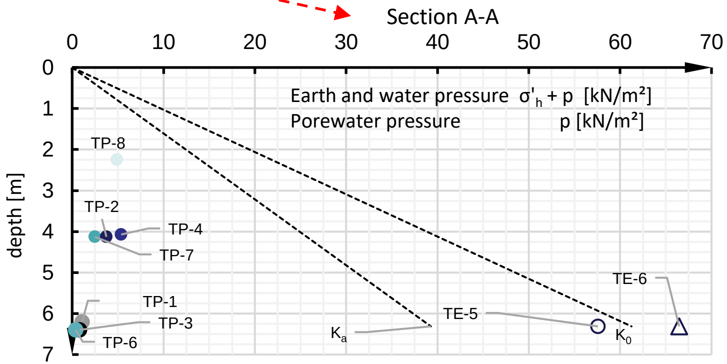


Hofmann, Berger, Wimmer (2021)

Water pressure on torrent barriers

- Measurements on different barriers with piezometer and earth pressure cells in Tirol





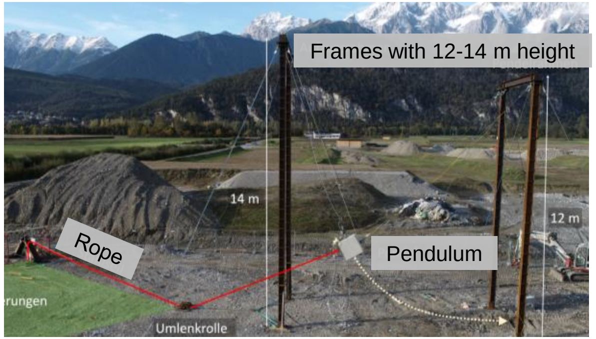
Hofmann, Berger, Steinwender & Wimmer (2022)

Time Capsule Project (TCP)

Research University of Innsbruck: Natural Hazards and Geotechnical Engineering

Foundations of rockfall protection fences

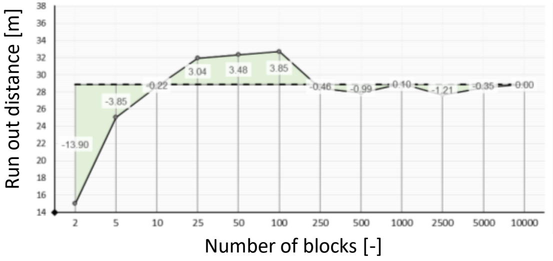
- Impact loading on micropiles and post foundations
- 100 field test on micropiles and foundation

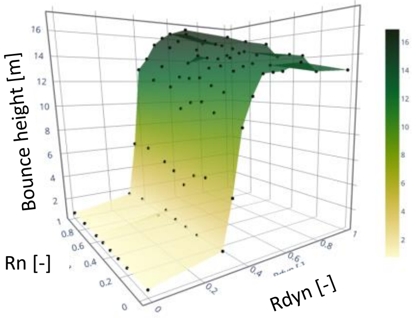


Hofmann, Wimmer, Berger & Steinwender (2020)

Rockfall simulations - convergence and sensitivity analysis - for design of foundations

- Determination of run-out distances and bounce heights (sensitivity analysis)

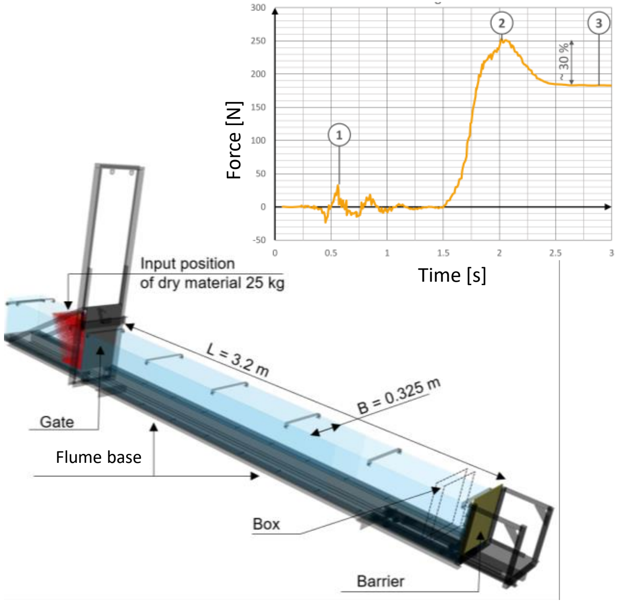




Hofmann, Berger (2021)

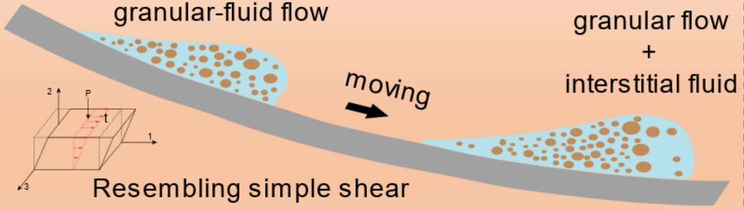
Impacts on barriers by flow-like gravitational mass movements

- 180 model test with different materials and barriers
- Back-calculation of the results from the model test with numerical simulations



Hofmann, Berger & Wimmer (2020)

Research BOKU: Constitutive Model for Granular Flows with Interstitial Fluids



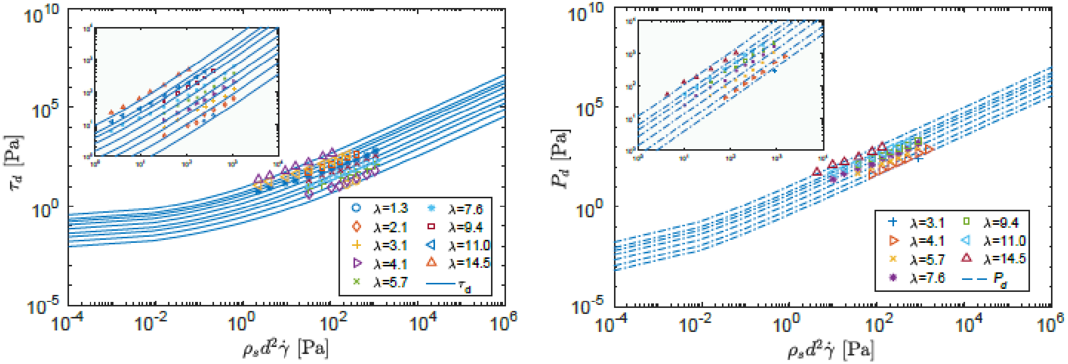
- Solid concentration significant affect dynamic behaviour
- Normal stress effect

Model framework

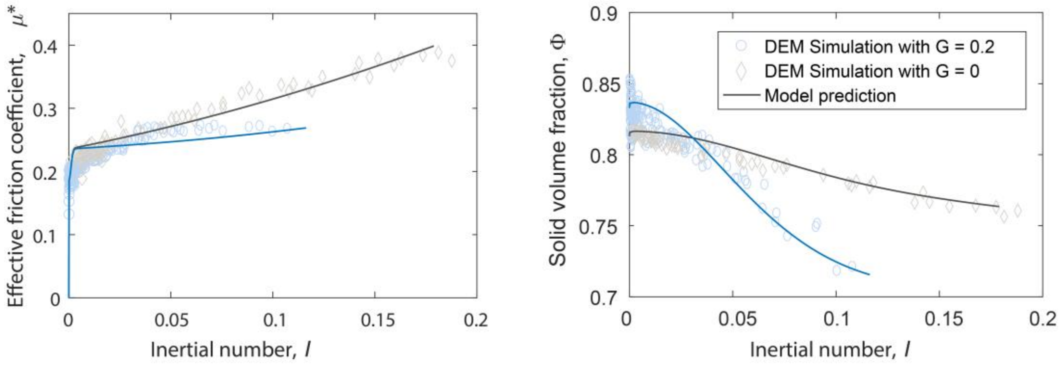
$$\dot{\mathbf{T}} = \dot{\mathbf{T}}_{hypo} + \dot{\mathbf{T}}_{dynamic}$$

Model equation

$$\dot{\mathbf{T}} = f_s\left[(\mathrm{tr}\mathbf{T}_h)\mathbf{D} + f_v(\mathrm{tr}\mathbf{D})\mathbf{T}_h + a^2\frac{\mathrm{tr}(\mathbf{T}_h\mathbf{D})}{\mathrm{tr}\mathbf{T}_h}\mathbf{T}_h + f_d a(\mathbf{T}_h+\mathbf{T}_h^*)\|\mathbf{D}\|\right] + \underbrace{(2K_1+4K_2\|\mathbf{D}\|)\dot{\mathbf{D}}}_{\text{shear stress}} - \underbrace{\frac{4K_2}{\tan\alpha_i}(\mathbf{D}\dot{\mathbf{D}}+\dot{\mathbf{D}}\mathbf{D})}_{\text{normal stress}}$$

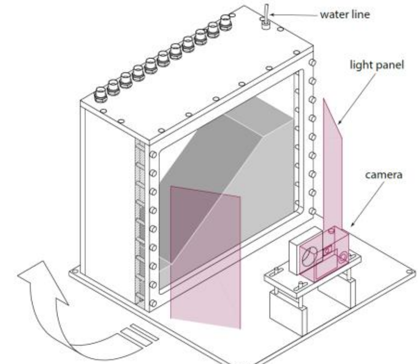


Comparison between experiments (Bagnold 1954) and prediction of granular-fluid flows with different solid concentration

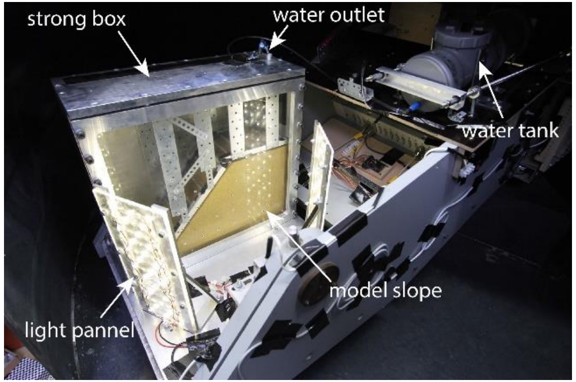


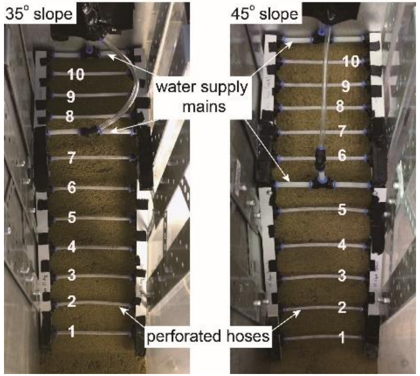
Comparison between model prediction and DEM simulations (Cruz et al. 2005) of dry dense granular flow in simple shear tests

Research BOKU: Centrifuge Modelling of Rainfall-Induced Slope Failure



Model container

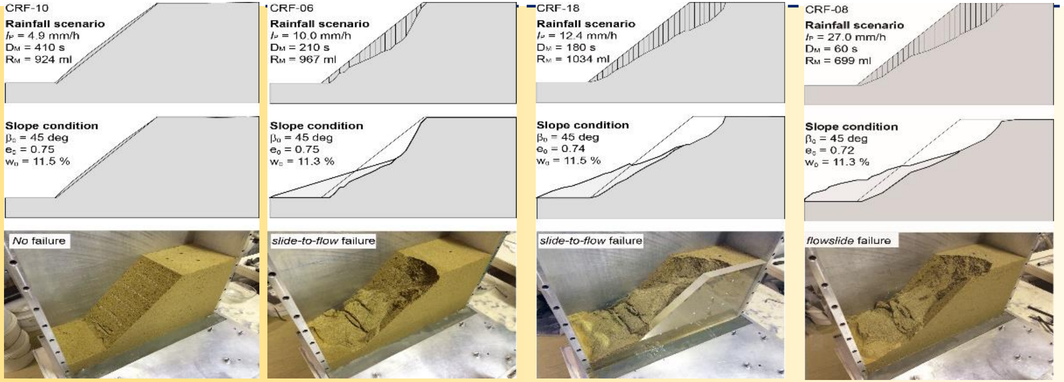




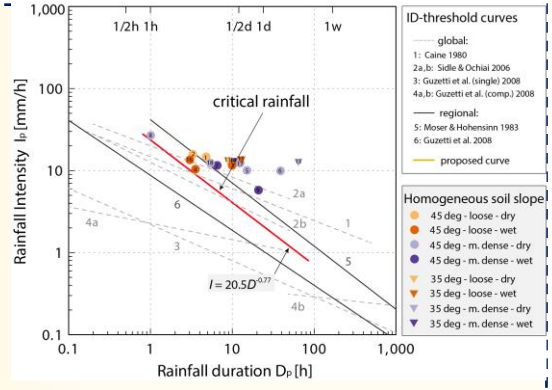
Centrifuge model with the rainfall system

The roles of rainfall intensity and initial conditions, such as slope angle, porosity and degree of saturation of the soil, in the failure initiation and post-failure kinematics are considered.

Most of the slopes exhibit a flow-type failure pattern, either following the slide-to-flow or the flowslide failure modes.



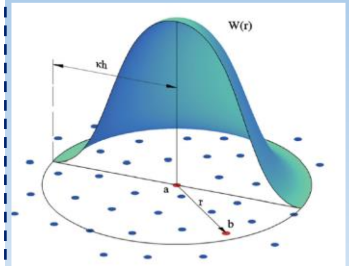
Failure patterns under varying rainfall intensity

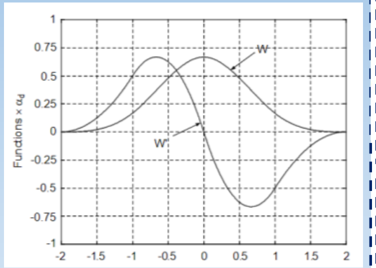


ID threshold curves

Research BOKU: Landslide Modelling with Smoothed Particle Hydrodynamics (SPH)

- Lagrangian particle-based method for convenient simulations of large deformations
- Various constitutive models for different material behaviours
- Massive GPU parallelization for large-scale modeling





Support domain and kernel function

SPH forms of governing equations

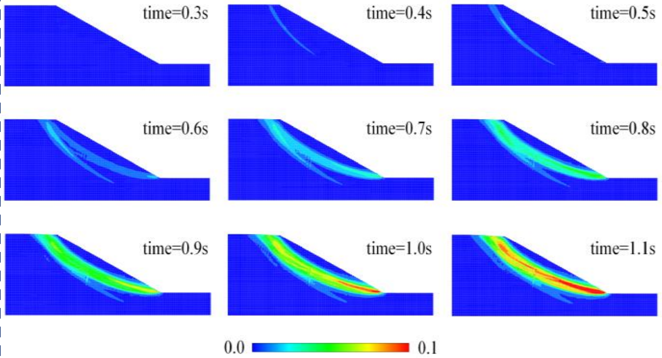
$$\frac{D\rho_i}{Dt} = \sum (\mathbf{v}_i - \mathbf{v}_j) \cdot \nabla_i W_{ij} m_j$$

$$\frac{D\mathbf{v}_i}{Dt} = \sum \left(\frac{\boldsymbol{\sigma}_i}{\rho_i^2} + \frac{\boldsymbol{\sigma}_j}{\rho_j^2} \right) \cdot \nabla_i W_{ij} m_j + \mathbf{f}_i$$

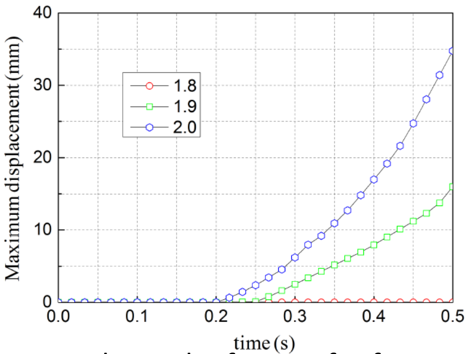
Constitutive models

Hypoplastic models

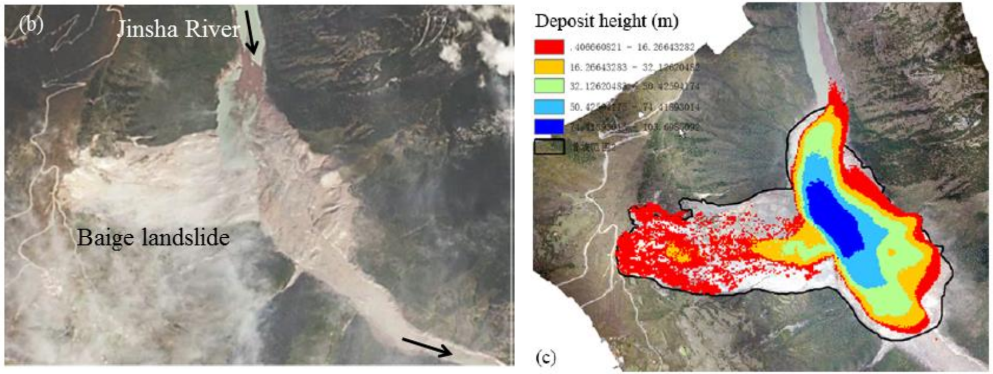
Elastoplastic/Viscoplastic models



Development of failure surface

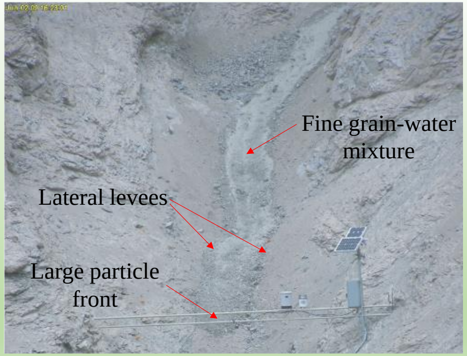


Evaluate the factor of safety

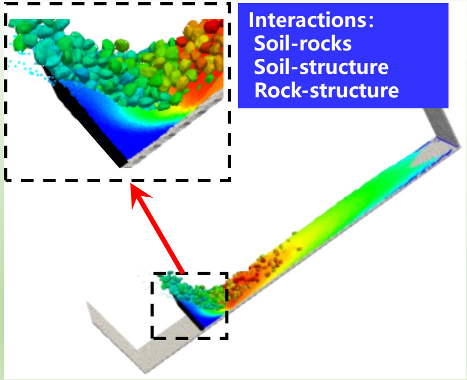


Three-dimensional large-scale modelling of Baige landslide

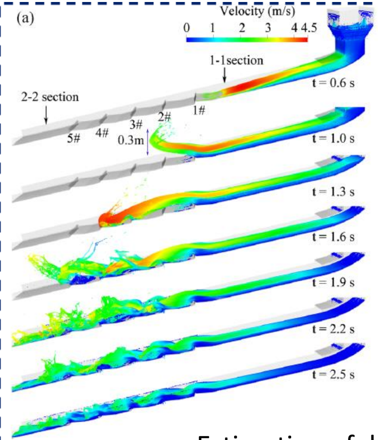
Research BOKU: Single Phase and Multiscale Modelling of Debris Flows (SPH-DEM)

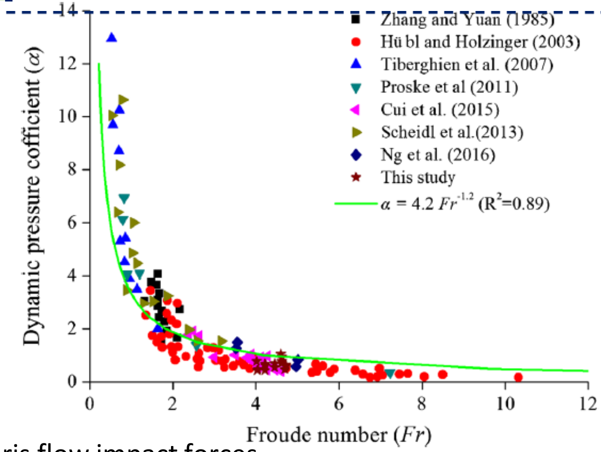


Multiscale phenomena: particle segregation interaction with structures

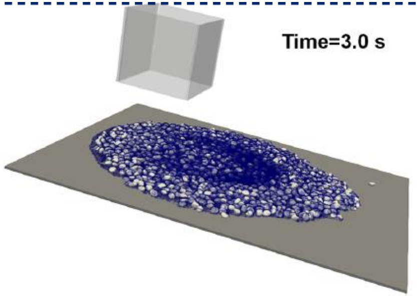


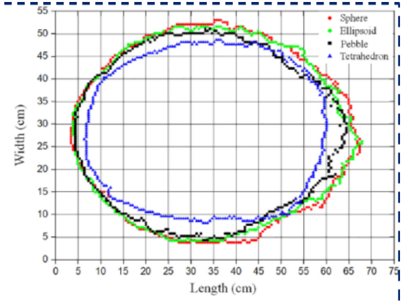
- A resolved SPH-DEM method for the multiscale modeling of debris flow
- DEM to consider arbitrarily complex rock shape
- SPH with elastoplastic/ viscoplastic models for the continuous phase





Estimation of debris flow impact forces





- Coupled modeling shows the strong impact of particle shape in debris materials
- Segregation and impact with structures can be modelled

Content

- **Personalities**
  - Karl von Terzaghi
  - Christian Veder
  - Heinz Brandl
- **Past and Current Research Activities**
  - TU Wien (TUW)
  - Graz University of Technology (TUG)
  - University of Innsbruck (UIBK)
  - University of Natural Resources and Life Sciences, Vienna (BOKU)
- **Miscellaneous**
  - International Projects of Specialist Contractors
  - Young Member Presidential Group
  - Conferences
  - Bid for 21st ICSMGE 2026 in Vienna

PAST

FUTURE

BAUER Spezialtiefbau

- **Silo Yard Silistra Project, Bulgaria**

- Execution of modern silos storage facilities with capacity of over 350,000 m for the leading company in the field of agricultural production and processing of grains and seeds (non-GMO; non- heavily treated crops) in Bulgaria
- Drilling of over 1,000 foundation piles with diameter 88 cm
- Construction period: 10/2021 – 10/2022



BAUER Spezialtiefbau

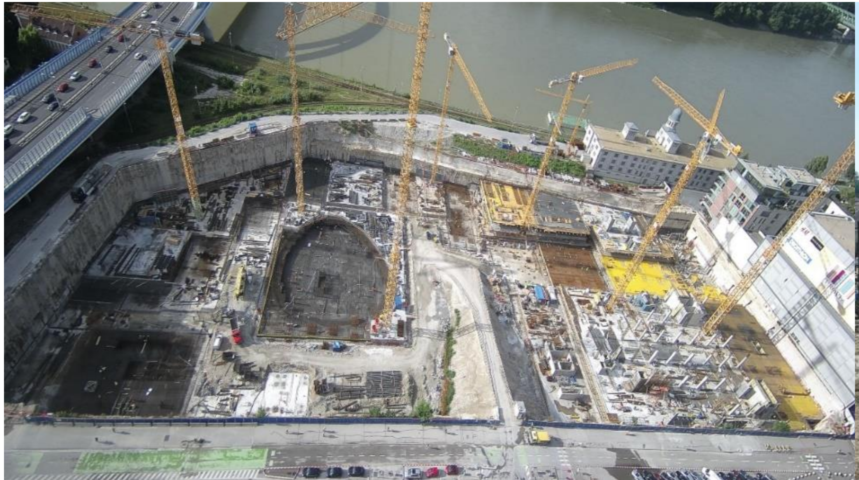
- **Bem Palace, Budapest, Hungary**
- Deep excavation: slurry walls 40 cm thickness, 3 rows of anchors and struts
- Construction period: 02/2021 – 02/2022

BAUER Spezialtiefbau

- **Dürer Park, Budapest, Hungary**
- Deep excavation: slurry walls 40 cm thickness, jet grouting, anchors
- Construction period: 05/2021 – 10/2021

BAUER Spezialtiefbau

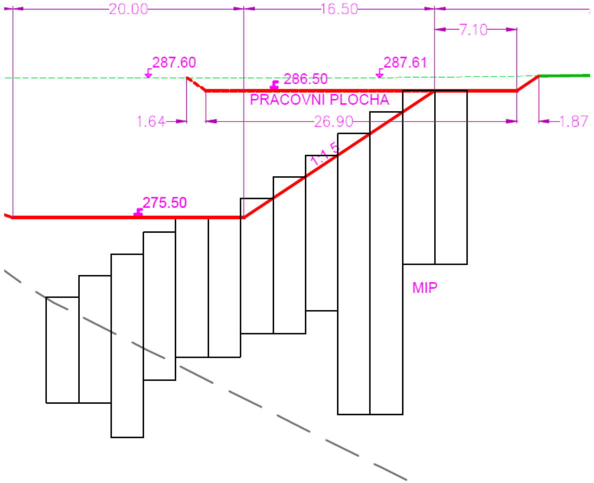
- **EUROVEA II, Bratislava, Slovakia**
- Deep excavation: single pile wall with jet grouting columns up to 30 m
- Foundation: totally > 21.000 m cased piles up to 41 m drilling depths with polymer slurry and CFA piles with diameter 88 cm up to 24 m depth
- Dewatering with 14 pumping wells for 858 days
- Construction period: 03/2019 – 02/2021




BAUER Spezialtiefbau

SO 02 Trial area, Coal Mine Bilina, Czech Republic

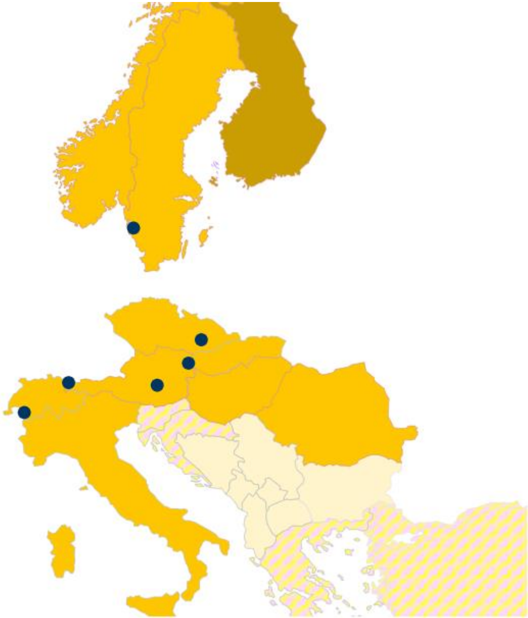
- Landfill stabilization
- Mixed-in-Place (MIP) panels as cement stabilization of landfill area
- 5.665 m^2 MIP elements up to 23.5 m depth
- Construction period: 07-08/2020



Keller Grundbau Ges.mbH

Keller South-East Europe & Scandinavia – headquarters in Vienna

- Support of nearly 900 construction sites each year



SÖDING AUSTRIA

Storage location manager: Hr. Friedrich Lasnik
Countries covered: All of SEN
Site area incl. buildings: 17,000m²

DORNBIRN AUSTRIA

Storage location manager: Hr. Roland Berthold
Countries covered: Vorarlberg
Site area incl. buildings: 1,200m²

VĚŽKY CZECH REPUBLIC

Storage location manager: Mr Luboš Krejčiřík
Countries covered: Czech Republic
Site area incl. buildings: 10,000m²

SAMORIN SLOVAKIA

Storage location manager: Mr Vladimír Ďurej
Countries covered: Slovakia, Austria
Standortfläche inkl. Gebäude: 7,000m²

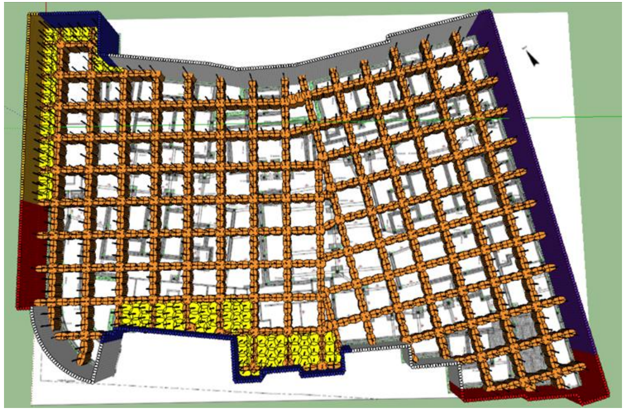
LINDOME SCHWEDEN

Storage location manager: Mr Michael Johansson
Countries covered: Sweden, Norway
Standortfläche inkl. Gebäude: 5,450m²

VÉTROZ SWITZERLAND

Storage location manager: tbd
Countries covered: Switzerland
Site area incl. buildings: 2,200m²

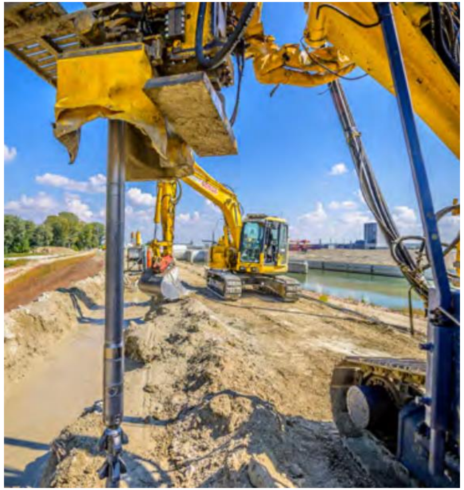
▪ St Barthélemy Island Project – Keller South-West Europe



- Foundation of new hotel complex with jet grouting
- Support of Keller with Austrian ACI® specialist

Keller Grundbau Ges.mbH

- **Moson Lock, Hungary**



- A lock in a tributary of the Danube river as part of an environmental rehabilitation project
- Jet grouting sealing slab – support of Keller with personnel and equipment

SMS2a, Norway

- Part of the intercity development project, which is part of the largest transport project in Norway, consisting of 270 km of new double-track rail
- Support of Keller with personnel and equipment

Eurovea 2, Slovakia

- Construction pit for a car park with four underground floors – part of the Eurovea 2 (public square, residential and commercial buildings)
- Support of Keller with anchorage know-how

- **Le Grand Paris (LGP) – Keller France**

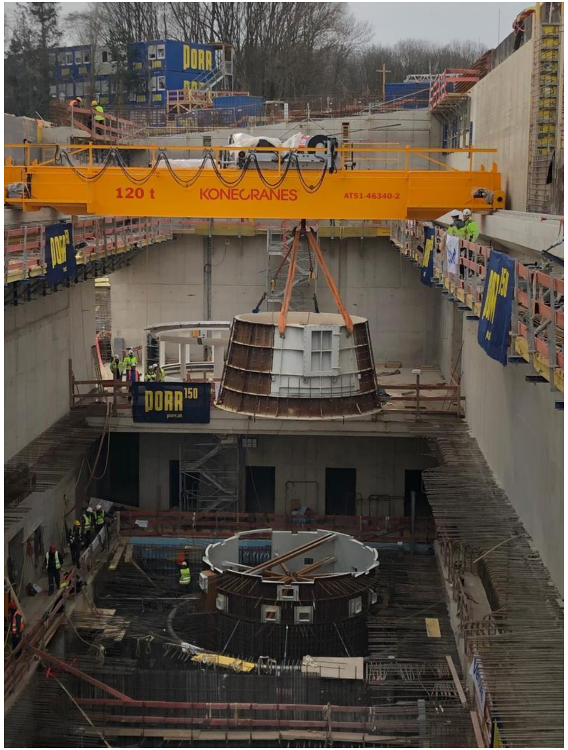
- Extension of the existing metro line in Paris
- Cooperation started in the tendering phase end ended with the deployment of site personnel and equipment on site

HPP Töging am Inn, Germany

The nearly 100 years old hydro power plant at river Inn in Töging, Bavaria, was reconstructed in the years 2020 to 2022.

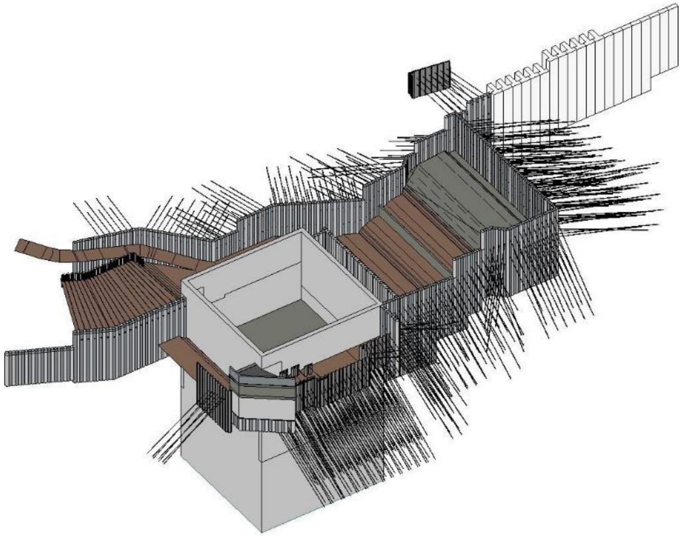
For the construction of the new power house heavy foundation works were necessary to depths of more than 70 meters. The complex ground and groundwater conditions on site were most challenging.

Diaphragm walls with 1.0 m thickness, jet grouting, anchors, board piles and complex dewatering processes were performed by up to 100 employees.



PORR Bau GmbH www.porr-group.com

- HPP Töging am Inn, Germany



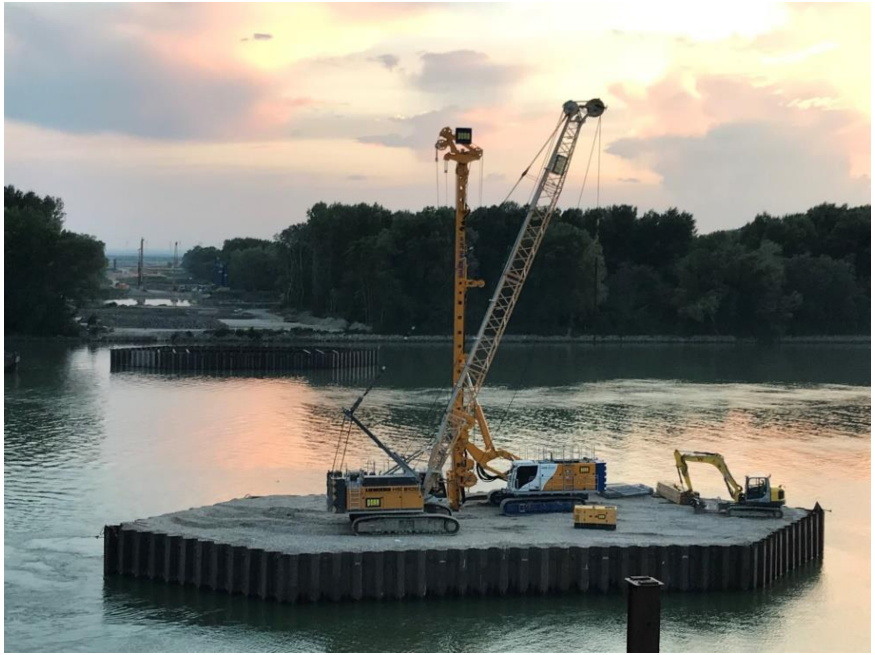
- **Motorway D4R7, Slovakia**

  The construction of the motorways D4 and R7 in the area of Bratislava required more than 30 deep excavations for bridge piers.

  Four out of them serve for the foundation of the piers in the Danube river for the new bridge over the Danube.

  Numerous sheet pile walls, jet grouting works and bored piles with a diameter of up to 180 cm were executed in the years 2017-2019.

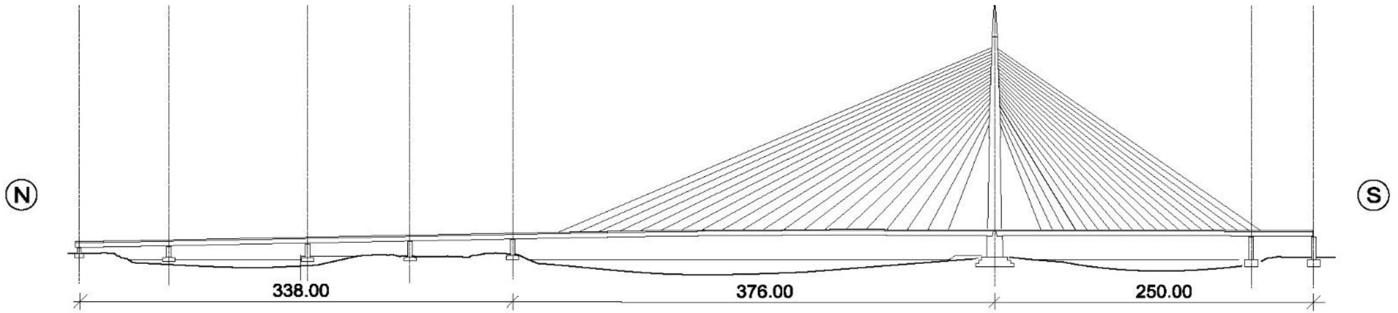
- **Motorway D4R7, Slovakia**



▪ Sava Bridge, Serbia

The construction works for the foundation of the new bridge over the river Sava in Belgrade were executed in 2008 and 2009. This bridge is still one of the largest cable stayed bridges in Europe.

The scope of work comprised the construction of the foundation for the 200 m tall pylon and six other piers of the bridge. Therefore diaphragm walls, piles, jet grouting and sheet pile foundations were carried out.



- **Sava Bridge, Serbia**

Züblin Spezialtiefbau Ges.m.b.H.

- **FAIR PARTICLE ACCELERATOR FACILITY**

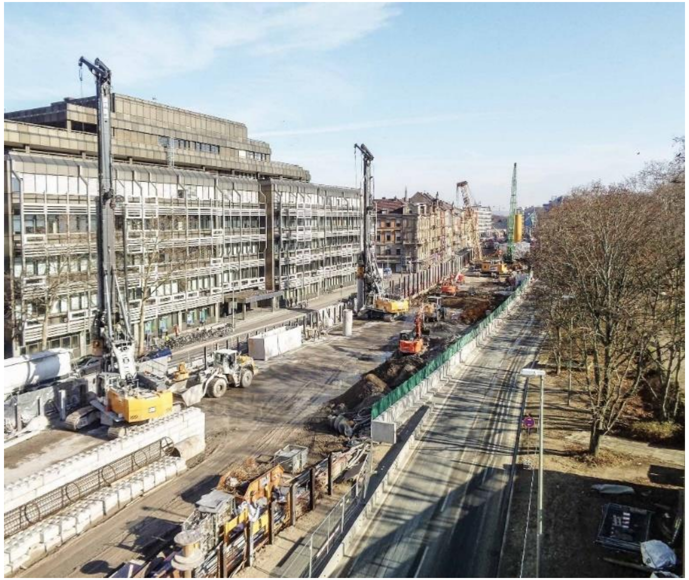
Darmstadt, Germany

DATA AND FACTS

- **Construction period:** 05/2017 – 12/2022
- **Client:** FAIR GmbH, Darmstadt
- **Work performed:**
  - More than 300 drilled wells
  - Complex dewatering system

▪ KRIEGSSTRASSE ROAD TUNNEL (COMBINED SOLUTION FOR KARLSRUHE)

Karlsruhe, Germany



DATA AND FACTS

- **Construction period:** 07/2017 – 09/2021
- **Client:** KASIG (Karlsruher Schieneninfrastruktur-Gesellschaft bmH), Karlsruhe
- **Work performed:**
  - Silica gel grouting for 35,000 m² horizontal sealing slab (ISI - Insond Seal Inject soft gel injection)
  - Jet grouting

Züblin Spezialtiefbau Ges.m.b.H.

- **TUNNEL BURG STABILIZATION**

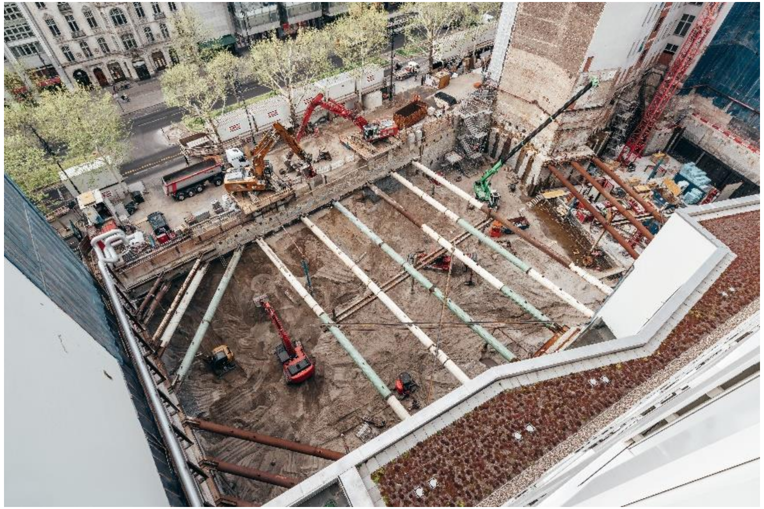
Küssnacht, Switzerland

DATA AND FACTS

- **Construction period:** 02/2018 – 05/2019
- **Client:** Joint Venture Baresel & Heitkamp
- **Work performed:**
  - Horizontal jet grouting
  - Preventer-protected injection boreholes
  - Preventer-protected drainage boreholes

- **GLORIA BERLIN JET GROUTING**

Berlin, Germany



DATA AND FACTS

- **Construction period:** 02/2018 – 04/2019
- **Client:** Centrum Ku'Damm 12, 13-15 GmbH und Co. KG
- **Work performed:**
  - Jet grouting for underpinning
  - Horizontal jet grouting slab

Züblin Spezialtiefbau Ges.m.b.H.

A63 CASTLE STREET IMPROVEMENT

Kingston upon Hull, United Kingdom

DATA AND FACTS

- **Construction period:** 2020 - 2023
- **Client:** Balfour Beatty / National Highways
- **Work performed:**
  - Soil stabilization (Dry Deep Mixing)
  - D-Wall
  - Tension piles
  - Horizontal jet grouting slab

Züblin Spezialtiefbau Ges.m.b.H.

- **STUREGALLERIAN FOUNDATION WORKS**

Stockholm, Sweden

DATA AND FACTS

- **Construction period:** 2021 - 2022
- **Client:** Sturegallerian Aktiebolag
- **Work performed:**
  - Jet grouting for underpinning

Young Presidential Group

- **Composition & Target Group**
  - Young professionals dedicated to all branches of geotechnical engineering
  - Universities & additional members from public & private sector
- **Mission & Aim**
  - Connect the next generation of geotechnical engineers
  - Establish inter-generational communication channels
  - Co-operational sharing of knowledge & ideas
- **Activities & Events**
  - Symposium, field trips & expert lectures
  - Next steps: Fireside chats & annual award

Hybrid Young Members Symposium
(Austrian Geotechnical Society, 2021)

Important Conferences

Past

- 1st Danube European Conference, Vienna 1964
- 2nd Danube European Conference, Vienna 1968
- 6th European Conference on Soil Mechanics and Foundation Engineering, Vienna 1976
- 16th European Young Geotechnical Engineers Conference, Vienna 2004
- 15th Danube European Conference, Vienna 2014
- 26th European Young Geotechnical Engineers Conference, Graz 2018
- 40 Years of Roller Integrated Continuous Compaction Control (CCC), Vienna 2018

Present

- Bi-annual Austrian Conference on Geotechnical Engineering in Vienna since 1997 including the Vienna Terzaghi Lecture
- Annual Christian Veder Colloquy, Graz since 1985

Time Capsule Project (TCP)

BID for 21st ICSMGE 2026

INVITATION TO VIENNA

INVITATION

Dear Members of ISSMGE,

In 1925 Karl Terzaghi published the book „Erdbaumechanik auf bodenphysikalischer Grundlage". On the occasion of the 100th Anniversary of this publication the Austrian Geotechnical Society as a member of the Austrian Association of Engineers and Architects and the Austrian Society for Geomechanics would like to take this opportunity to host the 21st International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE) in Vienna, Austria, due to the COVID-19 situation shifted to 2026.
The suggested theme of the conference **Geotechnical Challenges in a Changing Environment** provides a platform for developing new strategies for geotechnical engineering to cope with increasingly complex environmental requirements, last but not least in view of the consequences of the corona pandemic.
Vienna has an excellent reputation for being a top conference destination for holding conferences with several thousand participants and has been ranked as one of the worldwide top venues for more than 15 years. In addition, Vienna is a world class tourist attraction with a long history in music, museums and architecture.

- An experienced Organizing Committee under the leadership of Helmut F. Schweiger has been set up to ensure a smooth organisation of the conference.
- The Scientific Committee under the leadership of Dietmar Adam will guarantee a high standard of conference papers and make provisions that a large number of papers can be presented at the conference.
- A Young Geotechnical Engineers conference will be held prior to the main conference under the leadership of Franz Tschuchnigg who is dedicated to organize a memorable event for the younger generation of geotechnical engineers.
- Support of the local government will allow for moderate conference fees and support for developing countries.

We kindly ask for your support for this 100th anniversary initiative and look very much forward to welcoming you to the 21st ICSMGE in Vienna, Austria in 2026.




Heinz Brandl	Helmut F. Schweiger	Dietmar Adam	Wulf Schubert
Honorary President Austrian Geotechnical Society	President Austrian Geotechnical Society	General Secretary Austrian Geotechnical Society	President Austrian Society for Geomechanics

EXECUTIVE SUMMARY

WHY AUSTRIAN GEOTECHNICAL SOCIETY

- 2025 is the 100th Anniversary of Karl Terzaghi's publication "Erdbaumechanik auf bodenphysikalischer Grundlage" (published by Franz Deuticke, Leipzig and Vienna), which is widely recognized as „Birth of modern Soil Mechanics". Karl Terzaghi was Professor at the "Technische Hochschule" in Vienna (1929-1238) and established the first laboratory for soil mechanics worldwide.
- Karl Terzaghi founded the Austrian Society of Soil Mechanics and Foundation (now Geotechnical) Engineering in 1936 which was re-established after World War II in 1950. He was elected the first president of the International Society of Soil Mechanics and Foundation Engineering (ISSMFE) in 1936.
- Despite these close links with the International Society, Austria never hosted the International Conference. However, Vienna organized the 6th ECSMFE in 1976, so it would be a nice comeback of the Society to Austria after 50 years.
- Austria has a strong tradition in integrating geology, engineering geology, soil and rock mechanics, geomechanics and geotechnical engineering in practical applications. The sister society ISRM also has its origin in Austria and is closely linked to the name of Leopold Müller.
- Austrian specialist contractors and consultancies are well established at international level and will use the exhibition to present themselves to an international audience. As a consequence, the European Federation of Foundation Contractors strongly supports the bid for Vienna.
- The Austrian Geotechnical Society has a strong record of organizing conferences on a regular basis, such as the bi-annual National Conference, The Danube European Conferences in addition to specialist workshops and seminars. The Austrian Society for Geomechanics as co-organizer of ICSMGE 2026 also has a long-standing record of managing conferences such as the annual Geomechanics Colloquy in Salzburg with about 1000 participants and EUROCK conferences in 2004 and 2015.
- The Government of Vienna supports the conference in providing venues for the social programme. The conference will be organized as a green event.
- Funding will be provided to support participants from developing countries, in particular for young colleagues.
- A prominent speaker by one of the sister societies (ISRM, IAEG, IGS) will be given the opportunity to deliver a special lecture.

Austrian Geotechnical Society (1936 - 2022)

Presidents

K.v. Terzaghi 1936-1938

re-established in 1950

W. Aichhorn 1950-1972

H. Brandl 1972-2015

H.F. Schweiger since 2015
helmut.schweiger@tugraz.at

Secretaries

W. Steinbrenner 1950-1972

M. Fross 1972-2004

D. Adam since 2004
dietmar.adam@tuwien.ac.at

www.oiav.at/fachgruppen/fg-geotechnik/

Postal Address:
Austrian Geotechnical Society
ÖIAV - Österreichischer Ingenieur-und Architekten-Verein
(Austrian Association of Engineers and Architects)
Eschenbachgasse 9
A-1010 Vienna