

Durability of Anchorages

A Critical Approach to a Sensitive Topic



TAKING MICROPILES TO NEW HEIGHTS

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Contents and objectives of the lecture

In connection with the development of the new ÖN B4456, I will address the special requirements for grouted piles and nails in my presentation.

- Elimination of ambiguities in the designation
- Purpose of use
- Mode of action and impacts
- Problem areas
- Constructional requirements

Designations

Different designations in standards and other regulations, in daily language use often lead to misunderstandings, these are to be eliminated

- Grouted pile -General definition: Pile used in geotechnics for structures and rehabilitation with an outer diameter <300 mm, which transfers forces via its grout body into the surrounding soil or rock as a tension or compression pile - EN 14199 as drilled piles and EN 12699 for grouted displacement piles.
- ZVP = tension grouted pile according to RVS 08.22.01: tension loaded grouted pile. This definition also corresponds to the definition of a grouted pile commonly used in some states.
- Nails - Soil nails: fully, frictionally grouted to the soil, not prestressed. Bar-shaped structural element that forms a composite body with the surrounding soil as soil reinforcement - EN 14490.

applications

Micropile

- Grouted pile
- Anchoring of structures as a passive element
- Securing of excavation pits
- Soil stabilization

Soil nail

- Soil nailing - forms composite body with surrounding soil
- excavation securing - application of the composite body
- rock cross-links - tensile element

Mechanism

temporary –
semi
permanent -
permanent

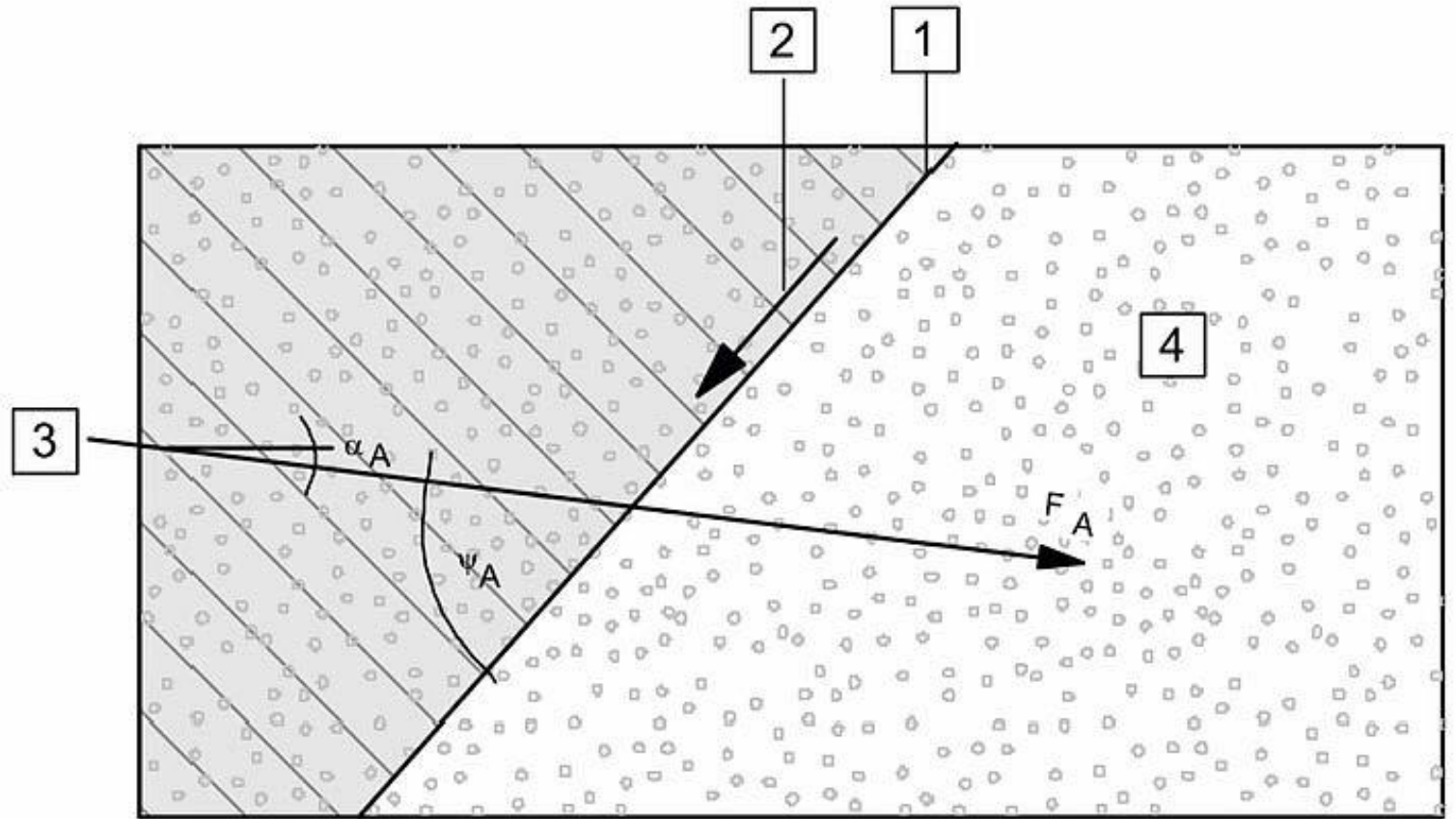
Micropiles

- Pure tensile element
- Shear element - shear stress
- Combined - tension/shear element

Soil nails

- Drawing element
 - Shear element
- together with bottom result in composite body

Definitions



Legend:

- 1 Shear surface
- 2 Direction of motion Sliding body
- 3 Tension member axis
- 4 not moving ground/rock



Impacts - exposures

- Actions from structure
 - Tensile loads - e.g. anchorages - permanent, temporary as live load, wind, snow, earthquake
 - Alternating loads - e.g. foundations of towers, wind turbines, supports, mast structures - wind, earthquake, live loads
- From soil - influence on corrosion behavior
 - Groundwater
 - Soil
 - Surface water or next to traffic routes
- Other effects
 - Stray currents
 - Lightning strike

Construction requirements 1

to micropiles and nails

- Design and planning
 - Damage consequence classes according to EN 1990:2013
 - CC1 - no danger to human life, minor economic consequences - embankments and slope stabilization on secondary traffic routes
 - CC2 - danger to human life and/or major economic consequences - embankments and slope stabilization on traffic routes
 - CC3 - Danger to many human lives and / or serious economic consequences - public infrastructure structures of high importance
- Planned service life
 - Temporary
 - Permanent

Construction requirements 2

to micropiles and nails

- Execution
 - Corrosion protection tensile element
 - Single corrosion protection - corrosion addition, coating, encapsulation
 - Double corrosion protection - based on EN 1537
 - Material corrosion protection - non-corroding materials
 - Corrosion protection grouting material - material-related co-protection
- Manufacturability
 - Adaptation to conditions on site
 - Choice of drilling method depending on soil and terrain conditions
 - Adjustment to climatic environmental conditions

Corrosion protection according to ON B4456

To micropiles and nails

Table 1 - Applicability of corrosion protection systems for grouted piles and nails depending on the load on the tension member

corrosion protection measure		impact/exposure		
		axial pull	axial alternating load	Combination of axial loading and ground deformations transverse to the tensile element axis
SPC	STA	X	X	X
	CCP	X	X	X
	ZCP	X	X	X
	GCP	X	X	-
DCP		o	o	o
MCP		o	o	o

meaning:

- not applicable
- o applicable without restriction of planned lifespan
- X suitable with regard to the design, depending on damage classes and corrosion loads

Definitions

- SCP – single corrosion protection
- STA – additional rust off rate
- CCP – coating
- ZCP – Galvanization
- GCP – grout corrosion protection, encapsulation
- DCP – double corrosion protection
- MCP – material corrosion protection

Design principles

- Redunant design for micropiles als tension members - additional number of micropiles depending on damage class

number of necessary tension piles/structural	minimum of necessary additional equivalent tension piles regarding damage		
	damage class CC1	damage class CC2	damage class CC3
1	1	1	1
≤ 4	≥ 1	≥ 1	≥ 2
>4 to 10	≥ 1	≥ 2	≥ 3
>10	$\geq 10\%^*$	$\geq 20\%^*$	$\geq 30\%^*$
**	In the design, the failure of the tension member(s) leading to the most unfavorable loading of the component shall be taken into account.		
*	percentage regrading the necessary tension piles/structural element		

Execution

- Top of micropile design regarding design lifespan
 - >2 years – for tension or/and alternating load piles with DCP a tight connection to DCp is essential
 - >2 years to <20 years – for tension or/and alternating load piles with SCP a CCP or ZCP 1,50 m long is necessary

Under environmental conditions that explicitly preclude the use of galvanizing, other suitable corrosion protection measures (STA, CCP, GCP, DCP, MCP) and a pile neck pipe are to be provided.

Execution 2

- Top of micropile design regarding design lifespan
 - >20 years – for tension or/and alternating load piles with DCP a tight connection to DCP is essential
 - >2 years to <20 years – for tension or/and alternating load piles with SCP a ZCP 1,50 m long is necessary, additionally a tight pile neck pipe has to be provided.
 - Alternatively a heat shrink tube >500 mm long may be used.

Execution 3

- Electrical separation of the steel tension member from the main reinforcement
- It must be ensured that the micropile and the reinforcement of the supporting concrete are electrically separated by means of an appropriate design or by installing spacers made of cement or plastic. In the event of corrosion in the grouted pile, this reduces the steel surface area involved in the corrosion and lowers the corrosion rate.

Areas of concern

During design phase

- Lack of involvement of the client in the determination of the damage consequence class and the requirements profile
- Incorrect estimation of the load-bearing effect
- Incorrect selection of corrosion protection measures
- Missing soil/subsoil investigations - Errors in the selection of corrosion protection measures
- Missing testing and monitoring concept

Areas of concern

During execution:

- Failure to take soil conditions into account
- Deviations during drilling
- Unsuitable drill bits
- Drilling diameter too small - Drill bit diameter
- Missing centering
- Cavities
- Groundwater flows

Construction supervision and monitoring

For each construction project, the use of a specialist construction supervision by the client – SCS-C - in accordance with table below is to be provided for the production of permanent and/or semi-permanent anchorages with piles depending on the damage consequence class

anchorage	damage class		
	CC1	CC2	CC3
semipermanent	a	a	b
permanent	a	b	b
a	the use of a specialist construction supervisor is determined in agreement with the client and its planner as required		
b	the use of a technical construction supervisor is obligatory		

Qualification and work to be done

- The SCS-C shall demonstrate extensive experience with anchoring elements by means of reference projects.
- Verifiable participation of the SCS-C in the instruction by the anchor system supplier
- Examination or suitability tests shall be carried out in the presence of the SCS-C.
- The documentation of the examination or suitability tests shall be checked.

Qualification and work to be done 2

Tasks before starting the work

- The SCS-C shall perform and document the following tasks prior to the start of the anchoring work:
- Review of the anchoring system planned and to be executed, especially with regard to the system-compliant anchor head design and its system-specific sealing;
- Review of the approval provisions submitted by the anchor system supplier;
- Determination of additional requirements in case of project-specific necessity.

Tasks prior to the start of installation of the anchoring system

- The SCS-C shall perform and document the following tasks prior to commencing installation of the anchorage:
- Participate in the anchor system supplier's briefing;
- Review at least one of the delivered anchoring systems for planned and contractual requirements;
- Verification that all components and construction materials required for anchorage system fabrication in compliance with the system and according to plan are available on site in a timely manner;
- Review of the execution records already available (e.g. drilling and grouting record, grout check).

Qualification and work to be done 3

Tasks during installation of the tension micropiles

- The SCS-C shall perform and document the following tasks during installation of the anchorage:
- Ongoing and random inspection of the storage conditions of the system components;
- Verification of system-compliant installation on at least 10% of the anchors to be manufactured;
- Review of all records of acceptance and suitability tests including records of leakage tests.

Tasks after fabrication of the tension micropiles

- The SCS-C shall perform and document the following tasks after fabrication of the anchorage:
- Review as-built documentation of the anchorage elements;
- If necessary, supplementing the as-built documentation with aspects of maintenance, servicing and ongoing monitoring.

Inspection of anchored structures

Anchored structures are all structures that have been designed and constructed using grouted anchors, grouted piles and nails in accordance with EN 1997-1-1. For older structures, which were erected according to the specifications of standards that have already been withdrawn or still without a basis of standards, a classification of the tension elements used shall be determined analogously according to the provisions of EN 1997-1-1.

The continuous monitoring, inspection and testing of anchored structures shall be carried out in accordance with RVS 13.03.21.

Finally some pictures

Difficult terrain
Planning as well as execution,
execution supervision and
acceptance tests posed great
challenges to all parties involved.
Formwork and reinforcement
work for an abutment of
Dachstein suspension bridge



Summary

Tension or alternating loaded micropile according to ON 4456

- If there is no evaluation of corrosivity in the soil, the soil is automatically classified as highly corrosive.
- the simplified procedure according to the following slide can be applied
- the type of the soil sampling - axial or axial and transversal has an influence on the measures to be taken
- Special regulations for micropiles
- GCP not allowed for transverse loading
- in case of presence of chloride load, salts, DCP should always be used for more than 7 years of service life
- For self-drilling systems, coating or galvanizing is not allowed
- redundant design for service life >20 and without DCP
- For non-redundant systems, DCP is required for CC1 from 50 years, CC2 from 7 years and CC3 from 2 years.

Summary



on to new shores - Tension Micropiles and nails can be durable and good-natured construction elements if designed and executed correctly!

Durability of Anchorages

a critical approach to a sensitive topic



Questions?



Thank you!