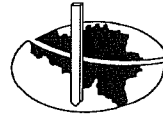




BBRI



BGGG - GBMS

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“Ground Anchors”

**General Framework and Viewpoint with regard  
to Ground Anchors, Soil Nails and Tension Piles**

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## 1. INTRODUCTION

When starting the BBRI research program on ground anchors there was a lot of discussion within the Working Group concerning the types of anchors to be tested. This was mainly due to the fact that there is no clear definition and/or classification of ground anchors. So the difference between ground anchors, soil nails and tension piles is not always clear.

The existing European Standards for ground anchors, micropiles and soil nailing contain a lot of valuable information. However a lot of cases exist which are not covered by the existing execution standards and/or by Eurocode 7.

## 2. EUROPEAN STANDARDS EXECUTION OF SPECIAL GEOTECHNICAL WORKS:

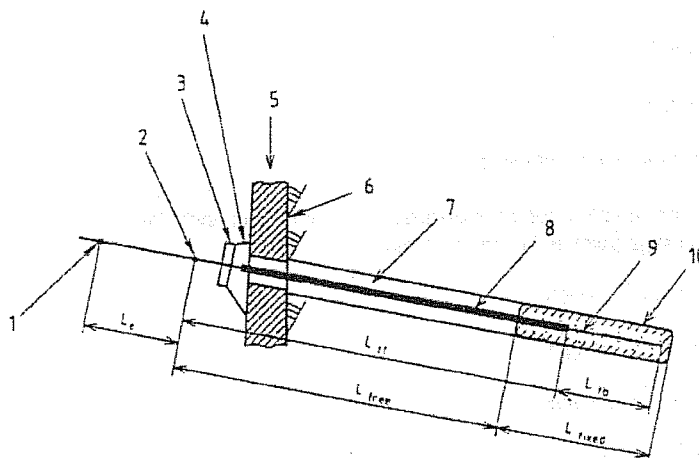
### 2.1. EN 1537 – 1999 : ground anchors.

#### Chapter 1 : Scope

*An anchor consists of an anchor head, a free anchor length and a fixed anchor length which is bonded to the ground by grout.*

#### Chapter 3 : Terms, definitions and symbols:

*Anchor : an installation capable of transmitting an applied tensile load to a load bearing stratum.*



#### Key

- |   |                    |
|---|--------------------|
| 1 Anchorage point at jack during stressing  | 6 Soil/rock        |
| 2 Anchorage point at anchor head in service | 7 Borehole         |
| 3 Bearing plate                             | 8 Debonding sleeve |
| 4 Load transfer block                       | 9 Tendon           |
| 5 Structural element                        | 10 Grout body      |

*Figure 1: sketch of a ground anchor – details of anchor head and head protection omitted.*

#### Chapter 9.7. acceptance test:

*Each working anchor shall be subjected to an acceptance test. The objectives ....*

#### Comment :

According to EN 1537 – 1999 a ground anchor has an anchor head, a free anchor length and a fixed anchor length and has to be subjected to an acceptance test.

*criteria and the equipment to be used for soil nail load tests. Table 2 suggests the frequency of soil nail load tests based on the category of geotechnical structure.*

Table 1 — Definition of soil nail load tests

| Purpose of test                                   | Type of Soil Nail Load Test   |  |  |
|---|---|--|--|
|   | Design Investigation Test   | Suitability Test   | Acceptance Test  |
|   | to investigate ultimate soil nail to ground bond resistance for design  | to verify the ultimate soil nail to ground bond resistance used in the design                | to demonstrate satisfactory soil nail performance at the acceptance load   |
| When tested                                       | Pre-design (if specified)   | Before or during production works  | During or on completion of production works  |
| Type of nail used                                 | Sacrificial   | Sacrificial  | Sacrificial or production  |
| Action taken in case of non compliant test result | Not applicable  | Review soil nail installation method and/or consider alternative soil nail length and layout | Consult designer for action to be taken and approval to continue   |
| Comments  | Caution should be exercised in applying investigation test results if type of nail & method of test nail installation is not the same as for the production works<br><br>It is not always possible to install test nails in body of proposed structure so results may not be representative | If necessary at each different soil layer  | Caution should be exercised when testing production nails not to overstress the nail to grout bond or cause damage to corrosion protection<br><br>When a structural facing is used the test nail should be debonded within the zone of influence of the facing |

Table 2 — Suggested frequency of soil nail load tests based on density of nails and geotechnical structure category

| Test type   | Suggested Minimum Frequency of Load Tests |  |  |  |
|---|---|--|--|--|
|   | Design investigation                      | Suitability  | Acceptance   |  |
|   |   |  | Number of soil nails per m <sup>2</sup> of slope > 1 per 1,5 m <sup>2</sup>  | Number of soil nails per m <sup>2</sup> of slope ≤ 1 per 1,5 m <sup>2</sup>  |
| Category 1: negligible risk to property or life   | Optional                                  | Optional   | Optional   |  |
| Category 2: no abnormal risk to property or life  | Optional                                  | If no comparable experience of soil type: a minimum of 3 test nails with at least 1 test nail per soil type.<br><br>Where direct experience exists then suitability tests are optional | For slope area:<br>≤ 1000 m <sup>2</sup> then 5 tests:<br>> 1000 m <sup>2</sup> then 1 test per 400 m <sup>2</sup><br><br>Above criteria subject to a minimum of 1 test per soil type and excavation stage | For number of nails:<br>≤ 200 – 3 tests<br>> 200 then test 1,5 %<br><br>Above criteria subject to a minimum of 1 test per soil type and excavation stage       |
| Category 3: all other structures not in category 1 or 2   | Optional                                  | A minimum of 6 test nails with at least 2 test nails per soil type.  | For slope area:<br>≤ 1000 m <sup>2</sup> then 5 tests<br>> 1000 m <sup>2</sup> then 1 test per 200 m <sup>2</sup><br><br>Above criteria subject to a minimum of 1 test per soil type and excavation stage  | For number of nails:<br>≤ 200 - 5 tests<br>> 200 - test 2,5 % of nails<br><br>Above criteria subject to a minimum of 1 test per soil type and excavation stage |
| NOTE 1 Geotechnical category of structure as defined in EN1997.   |   |  |  |  |
| NOTE 2 Test nails should be evenly distributed throughout the structure.  |   |  |  |  |
| NOTE 3 The frequency of testing is a suggested minimum.   |   |  |  |  |
| NOTE 4 Where Suitability Tests are carried out the number of Acceptance Tests can be reduced on a pro-rata basis. |   |  |  |  |

- Prestressing : not possible.

Comment :

This anchor types should be considered as tension piles (= micropiles working in tension) or soil nails.

The major problem with ground anchors in Belgium is that actually:

- there is no clear definition of a ground anchor;
- the design is done for all types of anchors with almost the same unit shaft resistances and with the same factors of safety.

So in most cases the execution method and the number of tests is not taken into account in the design.

## 4. PROPOSAL

### 4.1. Classification

In order to cover all types of ground anchors which are actually installed in Belgium the following classification is proposed :

- prestressed ground anchors;
  - passive ground anchors;
  - tension (micro)piles;
  - soil nails.
- a) Prestressed ground anchors :
- prestressed ground anchors may have a tendon element of high strength or low strength steel.
  - they always have a free length and a fixed length;
  - the fixed length is installed behind the so called active wedge and in this way that the necessary factor of safety is available for the overall stability;
  - they are always tested. When testing is not possible due to an excessive deformation of the retaining wall or the reaction system a higher value of the safety factor has to be introduced.
  - they are always prestressed by means of a hydraulic jack.
- b) Passive ground anchors:
- passive ground anchors always have a tendon element of low strength steel;
  - they always have a free length and a fixed length;  
the fixed length is installed behind the so called active wedge and in this way that the necessary factor of safety is available for the overall stability;
  - the number of tests to be performed has to be clearly specified in the tender documents and/or in the method statement;
  - it has to be demonstrated that the displacement of the anchor head is smaller than the allowable displacement of the retaining structure.
- c) Tension Piles:
- tension (micro)piles may have a tendon element of high strength or of low strength steel;
  - they have only a fixed length;

- suitability tests on working anchors?? (= not foreseen in EC7)
- acceptance tests on all working anchors.

b) Passive ground anchors:

- preliminary tests on sacrificial anchors
- suitability tests on sacrificial anchors
- suitability tests on working anchors?? (= not foreseen in EC7)
- acceptance tests on working anchors.

c) Tension piles:

- preliminary tests on sacrificial piles
- suitability tests on sacrificial anchors or on selected working anchors (provided with a free length for inclined anchors)
- acceptance tests on selected working anchors (provided with a free length for inclined anchors).

d) Soil nails:

- preliminary tests on sacrificial nails
- suitability tests on sacrificial nails.

## 5. CONCLUSIONS

In Belgium there is actually a lot of confusion concerning the design of ground anchors. This is mainly due to the fact that almost always the same design method is used regardless the installation method and the type and the number of tests performed.

The information given in the available European Standards is not precise enough to allow a correct design of all the types of anchors that are actually installed.

In order to obtain a better agreement with the actual daily practice it is necessary to extend EN 1537 with passive ground anchors and to define in EN 1997 (= EC 7) the safety factors which have to be taken in to account when acceptance tests are not performed on all working anchors. Further on it is proposed to elaborate a technical document dealing with the use of tension (micro)piles as anchoring elements.