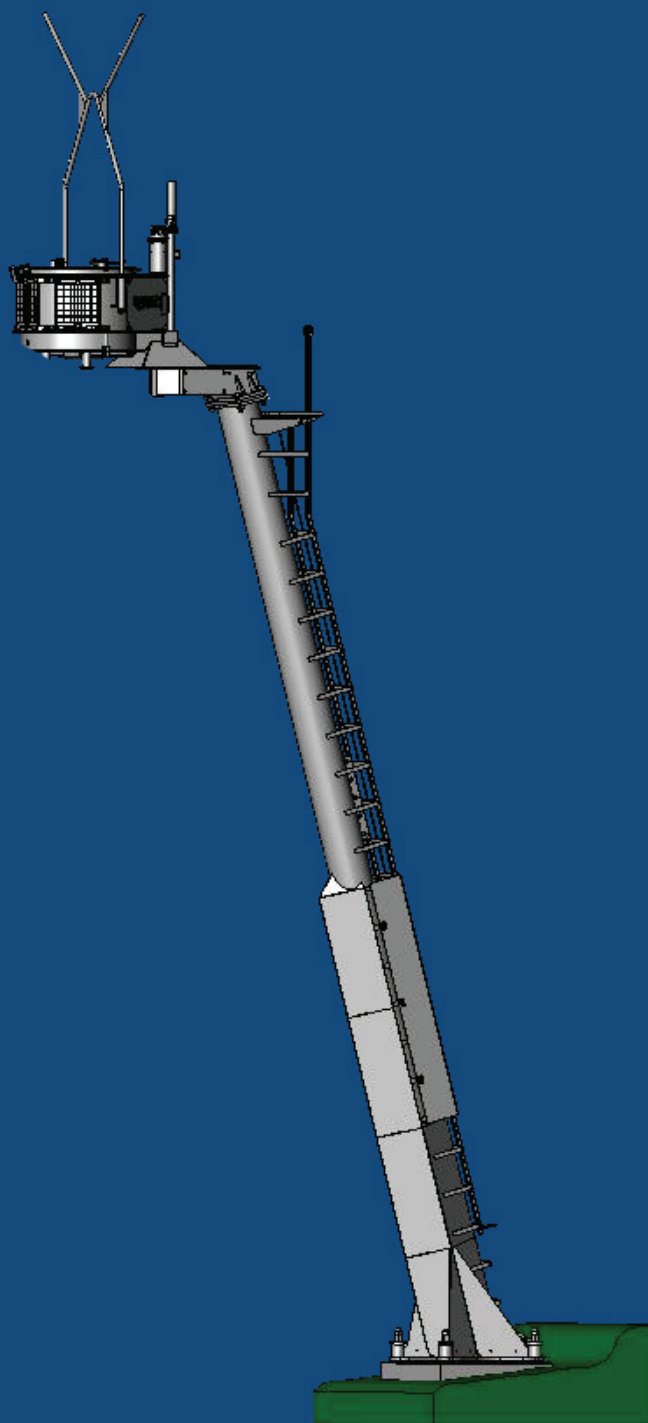


Foundation Instructions

Wyssen Avalanche tower LS12-5

Instructions for building the foundation and
erection of the tower



Snow is our element

Safety through technology is our strength

Safety Information

This manual contains information that must be observed for your personal safety, the safety of other persons and for the prevention of material damage. Such information is highlighted by a warning triangle and displayed depending on the degree of risk in the following manner.



Danger

Danger indicates that death or severe bodily injury will occur if the corresponding safety measures are not taken.



Warning

Warning indicates that death or severe bodily injury can occur if the corresponding safety measures are not taken.



Caution

Caution with a warning triangle indicates that light to moderately severe injury can occur if the corresponding safety measures are not taken.

Caution

Caution without a warning triangle indicates that material damage can occur if the corresponding safety measures are not taken.



Tip

Indicates useful or necessary user information.

Qualified Personnel

Personnel operating the Wyssen avalanche towers or the Wyssen helicopter latch must be officially appointed by the company management. Furthermore, the staff must also possess personal certification of training on the installations carried out by the manufacturer as well as a nationally valid licence for the artificial release of avalanches with explosives for operating the avalanche tower.

Instructions by colleagues within the company are not valid as a replacement for the installation training by the supplier. Persons who have not been trained by the supplier and who do not have the above-mentioned certification may not operate these installations.

If required, refresher training courses from the supplier may be requested at any time by the operator of the installations.

Intended Use

The avalanche tower is designed to trigger controlled avalanches by blasting. This is to safeguard avalanche-endangered installations, ski slopes, buildings, transport routes etc. where uncontrolled avalanches could lead to injury or damage to persons or property.

The intended use of this equipment is solely for the controlled release of avalanches and may only be operated by trained personnel in accordance with the regulations and after precise assessment of the current situation with regard to residual risks.

The installation is only to be used in conjunction with other devices and components that are recommended or approved by Wyssen Avalanche Control AG.

The proper and safe operation of the product requires correct transportation, assembly, storage as well as careful operation and maintenance.

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1 Description of the tower

1.1 General Information

The supporting tower is designed to hold the charge magazine, from which explosive charges are dropped and ignited by remote-control, in order to artificially release avalanches. Since the system is installed in potential avalanche slopes, the tower is exposed to the forces of snow and avalanche pressure if it is not located on a prominent elevation.

1.2 Dimensions and weights

The standard tower consists of 2 parts. A 5m high pedestal and a head end in lengths of 3, 5 and 7m. Thus the heights of the mast can be 8m, 10m or 12m.

The separate parts of the tower can be flown in either individually or as an assembled unit. The individual pieces weigh a maximum of 900kg, depending on the version; see table 3.7. They can thus be flown by almost any operating transport helicopter. The base plate is fixed with 4 vertical rock anchors or micropiles as well as a horizontal anchor on the upper slope side to relieve the shear forces. A concrete pedestal with a minimal surface area of 1m x 1m serves as a foundation.

1.3 Maximum forces on the tower and foundation

In order to check the resistance of the present construction method to avalanches, various avalanche scenarios were tested and for each scenario the pressure on the tower was calculated. The resistance to avalanches was tested with the aid of the calculations carried out and static analyses.

The tests showed that the impact of avalanches can be absorbed to a certain degree by the blasting installations, without any damage occurring to the equipment. However, it was also shown that very large avalanches can damage or destroy avalanche towers. In particular for possible avalanches that reach speeds of over 25m/sec. In addition to the impact of the flowing avalanche there is also a powder avalanche impact on the whole avalanche tower. In this case, a more precise testing by Wyssen Avalanche Control AG is necessary.

2 Building and installing the foundation

2.1 General Information

The commissioned builder is responsible for building and installing the foundation. It is absolutely necessary to comply with the details described in these instructions. Basically, the appropriate Swiss Guidelines for avalanche protection structures in the release zone, the ONR 24806 (Austria) and the current relevant national guidelines have to be considered when constructing or using rock anchors/micropiles. Any deviations in the details given in this document are to be reported to the manufacturer. The present instructions are based on the above-mentioned guidelines; however, in some cases modifications have been made to increase safety.

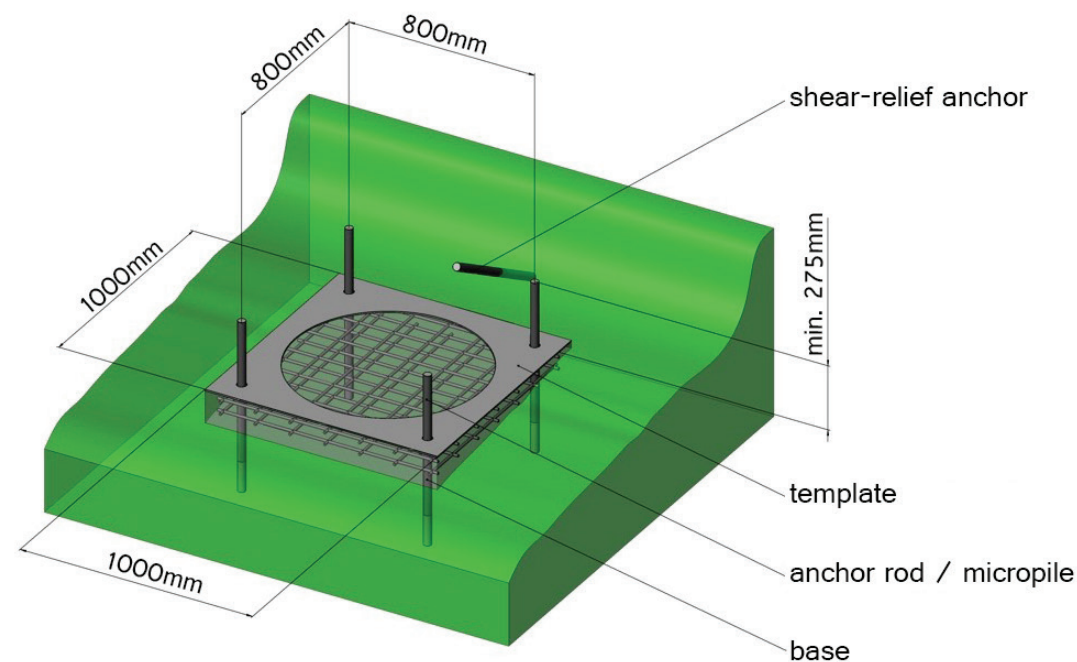
2.2 Earthing

The tower must be adequately earthed in order to protect the machine and persons. In the case of loose earth such as humus, sand or loose rock, the builder lays 3 radially arranged earthing straps with a cross-section of 3 x 30mm and a length of at least 25 m (in total at least 75m), and which are well earthed. The earthing straps must all have a hole of $\varnothing 14$ mm at one end for fixing onto the foot of the tower. The M12x30mm bolts, M12 nuts and M12 spring washers for fixing the straps to the tower are preferably attached to the strap prior to transportation.

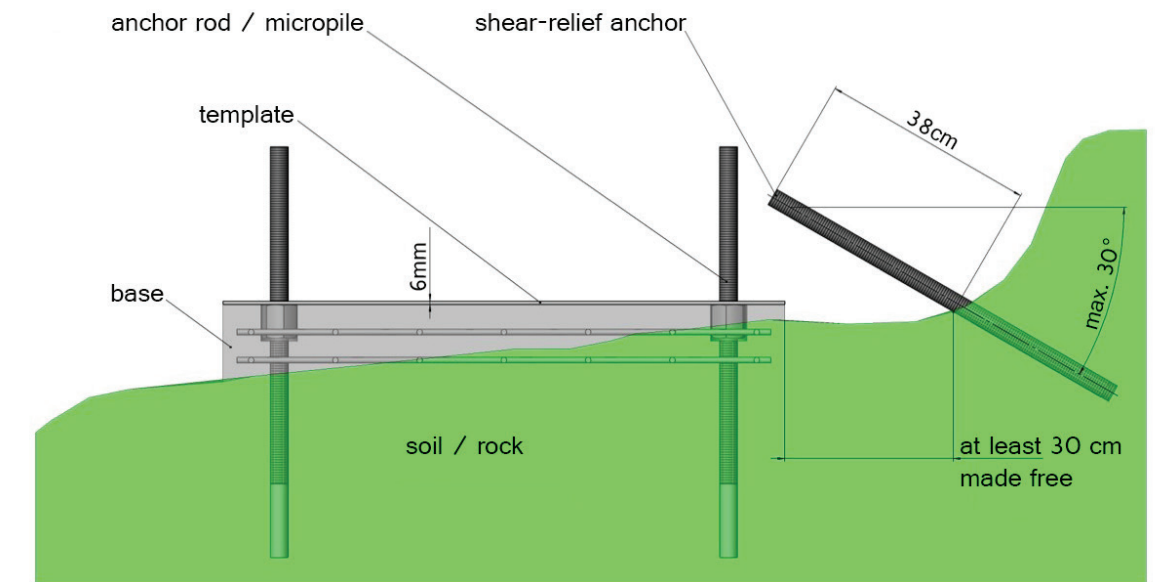
In the case that the tower location is predominantly on hard and compact rock, further assessments concerning earthing must be carried out by the Wyssen Company.

2.3 Layout and dimensions

The dimensions which are essential for the fitting to the base plate are shown in the figure below. It is important that the surface of the concrete base is exactly horizontal. The concrete may not protrude above the template.



Avalanche tower foundation



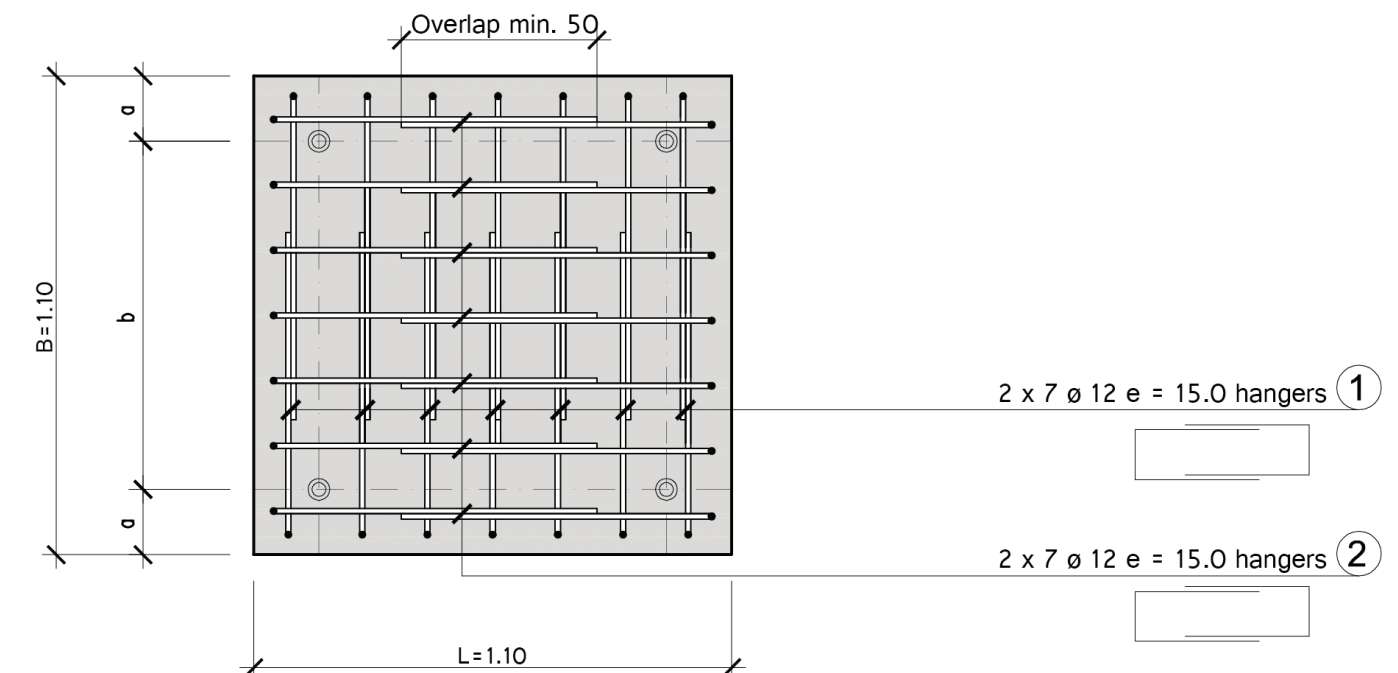
Shear-relief anchor design

2.4 Foundation by Rock Anchors or Micro Piles

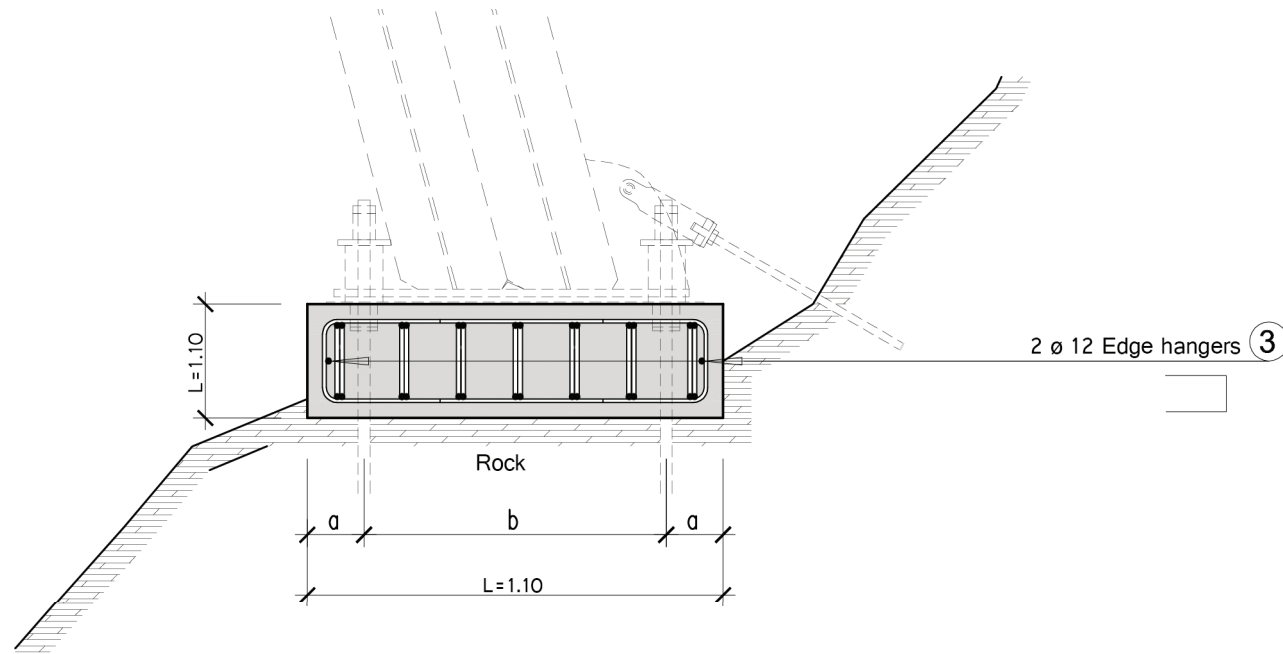
2.4.1 Structure of the Foundation

If not otherwise specified, the foundation by rock anchors and micropiles consists of a horizontal base whose side edges correspond with the line of the main slope lying underneath it. Four vertical anchors, a template as an anchor bond and an anchor for relief of shear forces. The drill holes must be prepared at the designated location in the terrain with the assistance of the pre-delivered template. After installation of the anchor/micropiles, the template is accurately aligned in the horizontal position and supported on the four anchor nuts.

After the location under the template has been thoroughly cleaned and loose stones have been removed, shutter boards can be prepared and pre-mixed dry concrete poured in under the template. After pouring the concrete it should be vibrated thoroughly. care must be taken to ensure the the complete template sits over the base and that no cement protrudes, so that a good even surface is guaranteed for the foot of the tower.

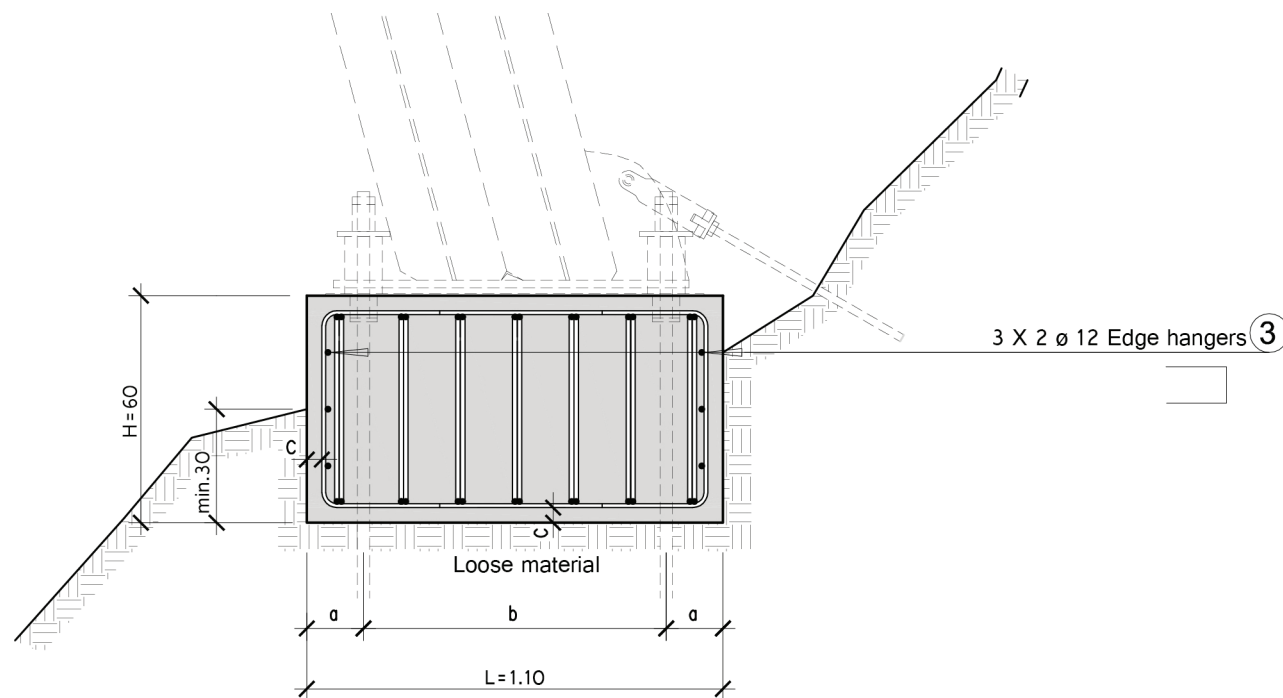


2.4.2 Foundation for rock



If the rock is solid, the concrete foundation is to be constructed with a thickness of 30cm according to the figure above.

2.4.3 Foundation for loose material



If the rock is loose, the concrete foundation is to be constructed with a thickness of 60cm. The anchoring depth of 30cm must be complied with.

The spacings a and b for the micropile boreholes and the shear-relief anchor are to be ensured according to the previous chapter. The reinforcement cover c is completed as follows:

- $c = 40\text{mm}$ generally
- $c = 50\text{mm}$ on prepared subsoil
- $c > 90\text{mm}$ on unprepared subsoil

2.5 Length of anchors and diameter of drill holes

In order that the maximum anchor strength can be attained in the vertical direction, the minimum anchor lengths must be compliant with according to the table below.

Type of anchor	Soil conditions	Anchor length in the earth	Drill hole
Rock anchor	rock largely free of fissures	min. 3.0m	min. 52mm
Micropile / self-drilling anchor*	Medium soil	min. 5.0m	min. 90mm
	Poor soil	min. 8.0m	min. 90mm*
	Drill hole $\varnothing 70\text{mm}$ possible for coated anchor		

Definition of poor soil:

Loose soil, non-cohesive, non-binding fine material (e.g. moist, clayey weathered products that only allow poor interlocking with the anchor and the soil), scree.

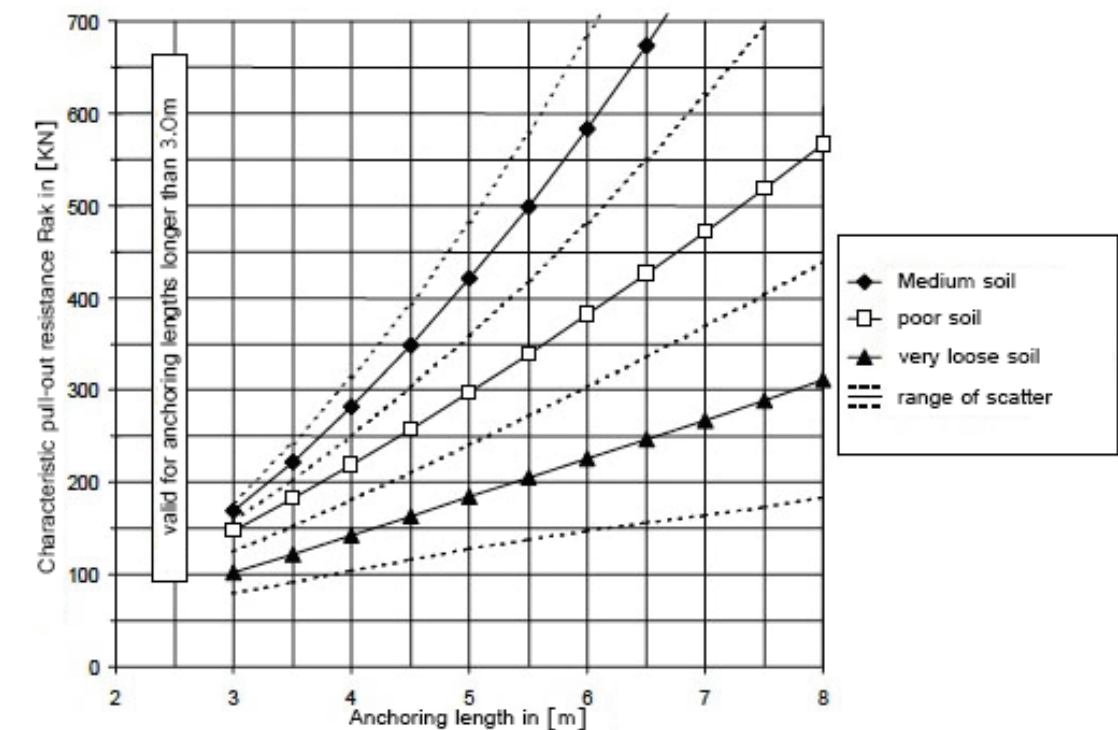
Definition of medium soil:

Densely packed with cohesive fine material (e.g. coarse scree blocks with some parts of binding fine material, dry gravel sand).

2.5.1 Assessment and differentiation of the soil types

The following characteristic pull-out resistances of the soil, taken from the Swiss Guidelines for avalanche protection structures, are adopted for pre-dimensioning the anchor lengths.

The final specification of the anchor lengths takes place on location by establishing the pull-out resistances during assessment of the soil by the contracting company / geologists.



Calculation of characteristic pull-out resistance

2.5.2 Rock anchors

Provided that sound rock is found in the subsoil, the foundation can be started with rock anchors. The following requirements must be observed:

- ✗ The drill hole diameters must be at least 1.5 times greater than the anchor diameter.
- ✗ The minimum grout cover of the anchor must be 10 mm (corrosion protection).
- ✗ The anchor lengths must be specified corresponding to the maximum forces and the rock quality. The first half metre in the rock may not be included in the calculation. The minimum length of the anchors is 3.0m.
- ✗ The anchor bar is to be centred in the drill hole.
- ✗ Before injecting grout into the drill hole, it must first be cleaned by blowing out.
- ✗ A suitable anchor grout is to be used that is low-shrinkage and is capable of swelling.
- ✗ The drill hole must be filled with grout from the bottom, so that the anchor bar is grouted full-face and without air pockets.

2.5.3 Micropile

Micropiles are used for medium or poor soils, and are particularly sensitive to shear forces, since in contrast to rock, such forces cannot be absorbed by the relocated soil. The following requirements must be observed:

- ✗ The minimum drill hole diameter is 90 mm.
- ✗ The maximum mesh width of the net stockings is 10 mm; however, if possible the use of a stocking is to be avoided.
- ✗ The grout cover of the anchor member must be at least 20 mm.
- ✗ The anchor lengths must be specified corresponding to the maximum forces and the soil quality. The first half metre in the soil may not be included in the calculation. The minimum length of the anchor is 5m.
- ✗ The anchor is to be centred in the drill hole.
- ✗ The drill hole must be filled with grout from the bottom, so that the anchor bar is grouted full-face and without air pockets.
- ✗ If larger anchor diameters have to be utilised due to the geology, then adapters have to be used in the area of the foundation.
- ✗ A suitable anchor grout is to be used that is low-shrinkage and is capable of swelling.

2.5.4 Shear-relief anchor (horizontal anchor)

The shear-relief anchor must be set up according to the instructions in chapter 2.3 An additional jig may be obtained from the Wyssen Company for drilling the shear-relief anchor. The anchor bar must be centred in the drill hole, which can be achieved by using a spacer or centring components. The anchor must not be installed at an angle flatter than 15° to the horizontal. The minimum length of an anchor is 6m. The final length will be decided upon by Wyssen Avalanche Control AG.

If a reinforced tower is utilised, a minimum free working length of 1m is to be included for the anchor. This is achieved by overlaying a PVC tube beforehand with a marginally larger diameter than the anchor. The 70cm long PVC tube must be flush with the earth and reach into the interior.

2.5.5 Record book and confirmation of execution

A record book with the Company's stamp and signature, containing at least the details listed below, is to be drawn up and presented to the client.

General Information:

- ✗ Name and address of the contracting company
- ✗ Name of the builder on location
- ✗ Execution date

Anchor data:

- ✗ Number and diameter
- ✗ Anchoring lengths
- ✗ Situation and inclination of each anchor
- ✗ Anchor capacity

Drilling:

- ✗ Drilling process
- ✗ Borehole length and diameter
- ✗ known drilling obstacles
- ✗ Sketch of the subsoil properties encountered while drilling

Grouting:

- ✗ Type of cement
- ✗ Cement consumption
- ✗ W/C ratio
- ✗ Additives
- ✗ Type of injection
- ✗ Temperature and weather conditions



Tip

In addition to the record sheet, a confirmation of the execution is to be handed over in which the contacting company confirms that the foundation and assembly has been carried out in accordance with the present instructions and the state of the art. There is a template for this in the annex.

2.5.6 Material required for construction of the foundation (excluding general building tools)

Number	Article	Dimension Comments	Supplier Material
1 pc	Template	l x w x h: 1000 x 1000 x 6 mm Weight: 25 Kg	Wyssen Avalanche Control AG
4 pcs	Anchor rod	nominal-ø: Length:	e.g. SwissGewi anchor from SpannStahl
8 pcs	Anchor nut	nominal-ø: 32 mm / Length: 60 mm	ditto
4 pcs	Lock nut	nominal-ø: 32 mm / Length: 30 mm	ditto
3 pcs	Earthing strap	Cross-section: 3 x 30 mm Length: 3 x 25 m (total at least 75 m) Galvanised steel or copper	Galvanised steel or copper
	Anchor mortar	Quantity according to supplier's details and depth of anchor	e.g. Avalanche defence mortar from Sakret
	Dry concrete	For base, quantity dependent on terrain	
2 pcs	Reinforcing grid	l x w: 1000 x 1000 mm Wire diameter: 8 mm, mesh width 15 cm Material: e.g. K335	
	Water	Plan in sufficient quantity.	
Additional material for the shear-relief anchor (horizontal anchor)			
1 pc	Drilling jig Shear-relief anchor	l x w x h: 940 x 480 x 380 mm Weight: 30 kg	Wyssen Avalanche Control AG
1 pc	shear-relief anchor	Wyssen Art. Nr. 411.430A consisting of: Anchor hub: 411.435 Support plate: 411.437	ditto
1 pc	Hex bolt	M36 x 120, DIN 931	ditto
1 pc	Safety hex nut	M36, DIN 985	ditto
1 pc	Anchor rod	nominal-ø: 1.0 or 40 mm Length: depending on the foundation (+ +10 cm to the drilling depth)	e.g. SwissGewi anchor from SpannStahl
1 pc	Lock nut	nominal-ø: 1.0 or 40 mm Length: 30 mm	ditto
1 pc	PVC tube	nominal-ø: 34 mm or 42 mm Length: 70 cm (Only for reinforced towers)	Wyssen Avalanche Control AG

2.5.7 Important when leaving the construction site - preparatory work for assembly

After completion the foundation must be left so that the tower can be assembled without any further preparation.

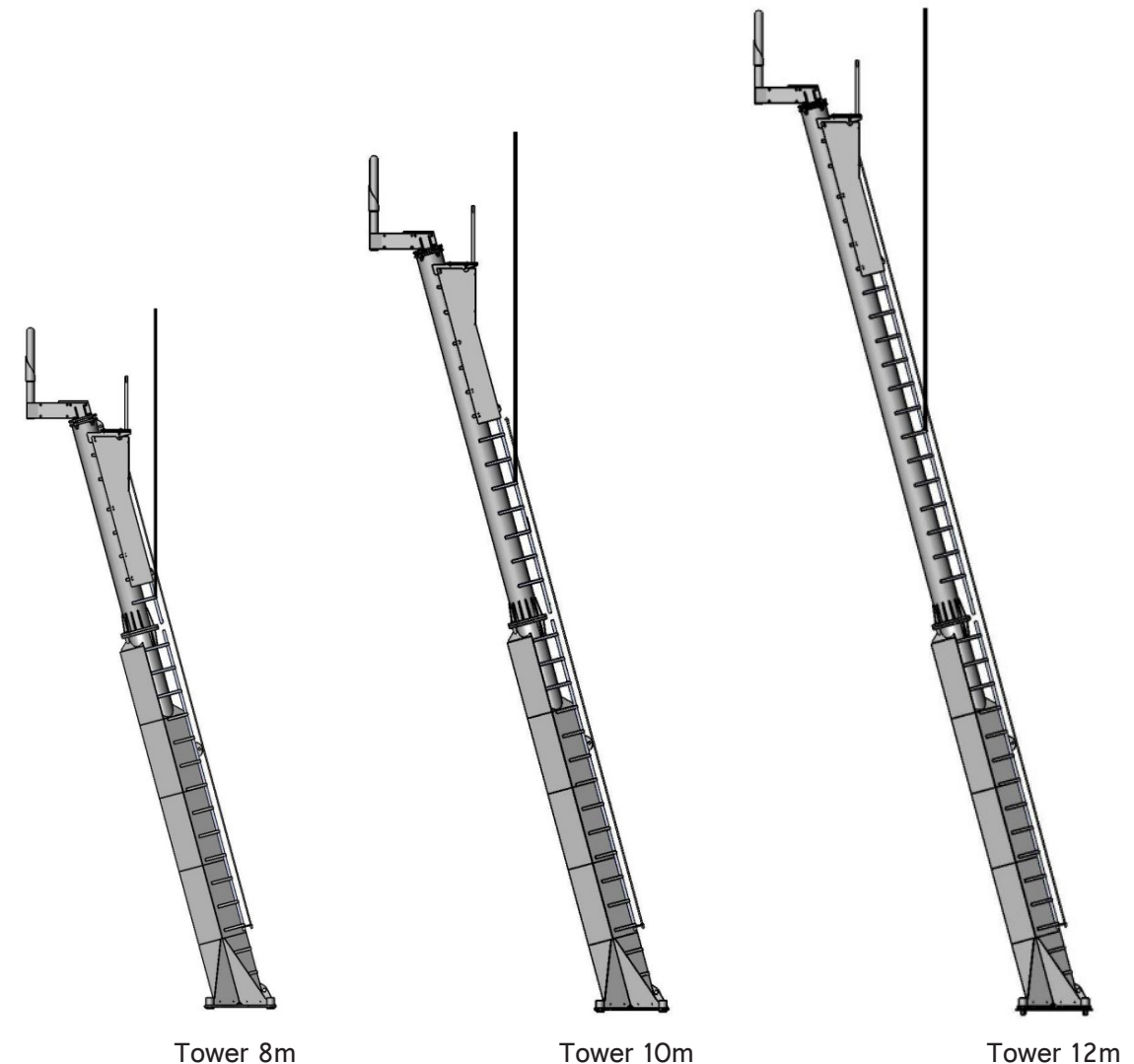
- ✘ An anchor nut and lock nut must be prepared for each anchor rod.
- ✘ The thread must be clean, so that the nut can be freely threaded by hand.
- ✘ There must be no surplus material on the base that is higher than the template.
- ✘ Shear-relief anchor rods must be sawn off flush with the template.
- ✘ The construction site must be left clean.

3 Erection of the tower

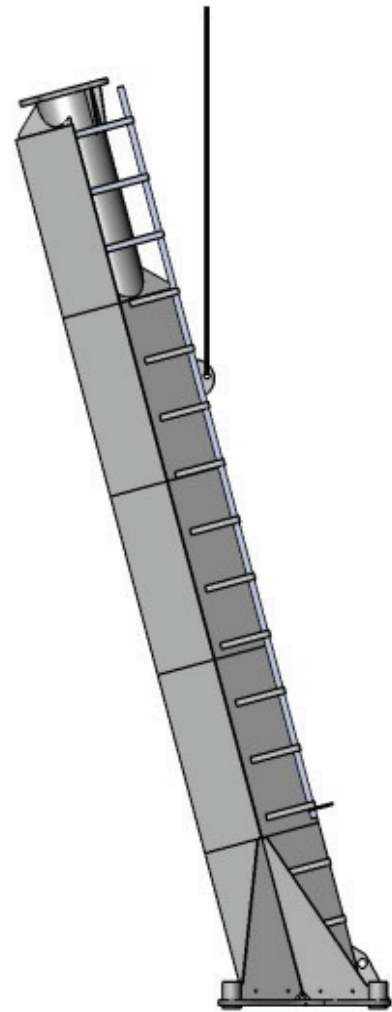
3.1 Placement of the complete tower

It is very important that material and tools required according to tables 2.5.6, 3.6.1 and 3.6.2 are placed ready at the foundation before placing the tower. In addition the assembly mandrel, onto which the magazine is placed, must be thoroughly cleaned and lubricated with a cold-resistant grease.

The elements of the two-part tower can be transported either individually or as an assembled unit. For helicopter transport these are suspended from a single point for easier assembly, transported and set down at the foundation. At least 3 men are necessary for acceptance of the tower and its alignment over the foundation anchor rods.



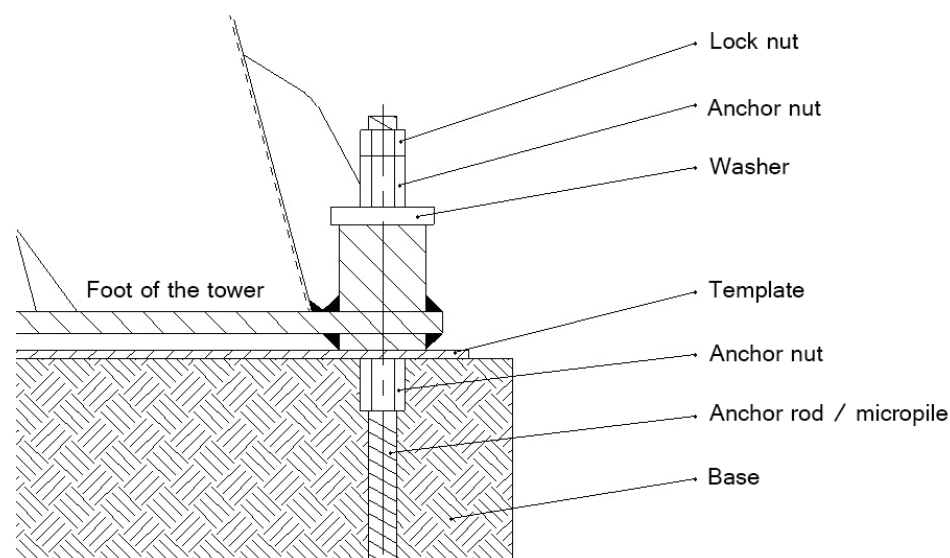
3.2 Placement of the pedestal of the 2-part tower



Pedestal of the 2-part tower with fixation point for helicopter transportation

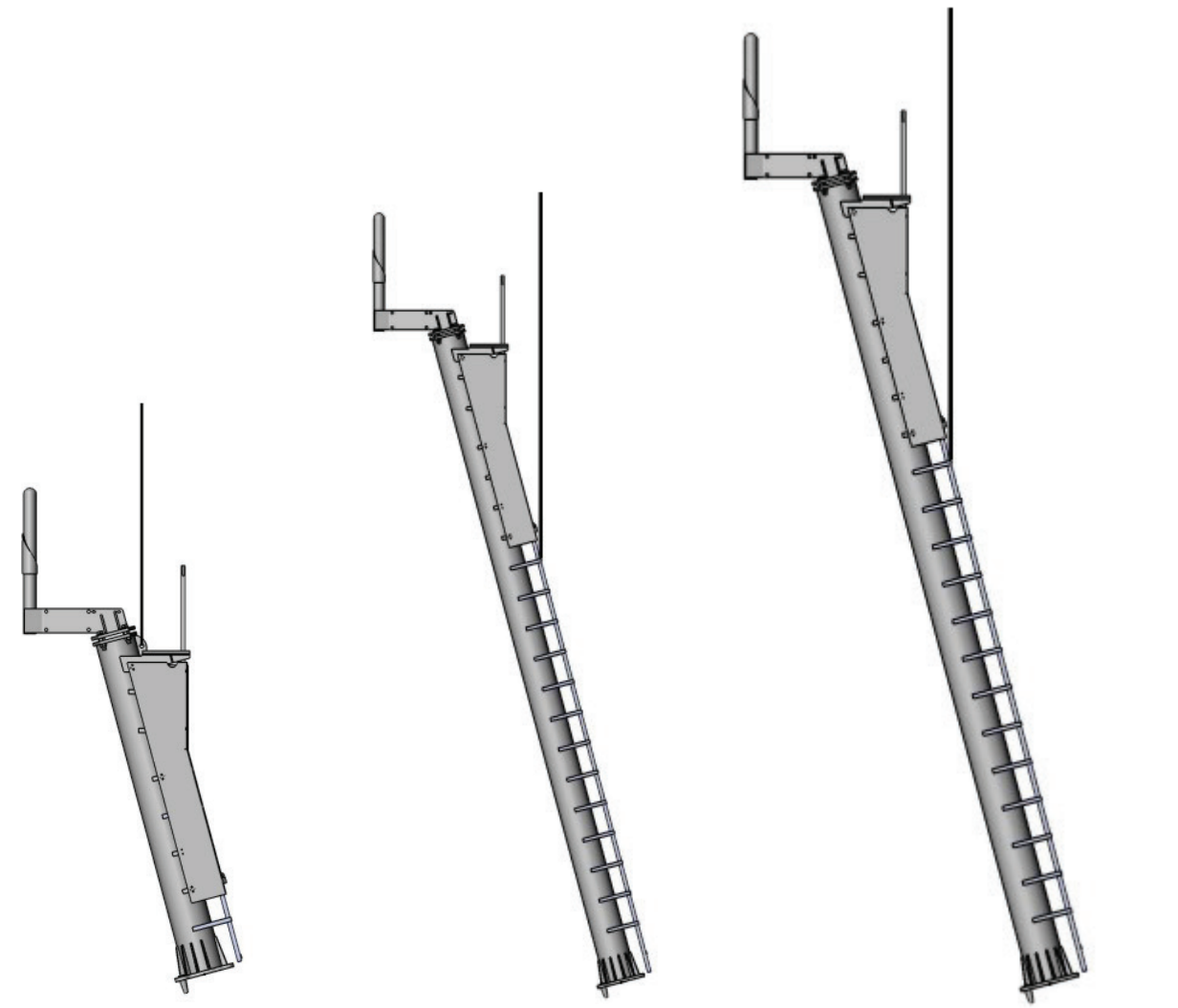
The weight of the tower's pedestal is given in table 3.7.
After the tower pedestal has been set down, the 4 U washers and then on anchor nut per anchor rod must be fitted and tightened by hand, before the helicopter completely releases its load.
Afterwards the nuts can be tightened with the torque wrench and finally the half nuts can be locked in place.

At the end the anchor head piece is protected with a bandage impregnated with an anti-corrosion compound.



Tower pedestal configuration

3.3 Placement of the top pieces of the 2-part tower



Tower pedestal 3m

Tower pedestal 5m

Tower pedestal 7m

The weights of the above towers are also given in table 3.7.

The tower top piece is brought by helicopter to the pedestal. For precise positioning, the conical pins are guided into the corresponding feed holes in the pedestal. On the upper slope side at least 4 M-20 bolts must be fully tightened by hand before the helicopter pilot can release the load.

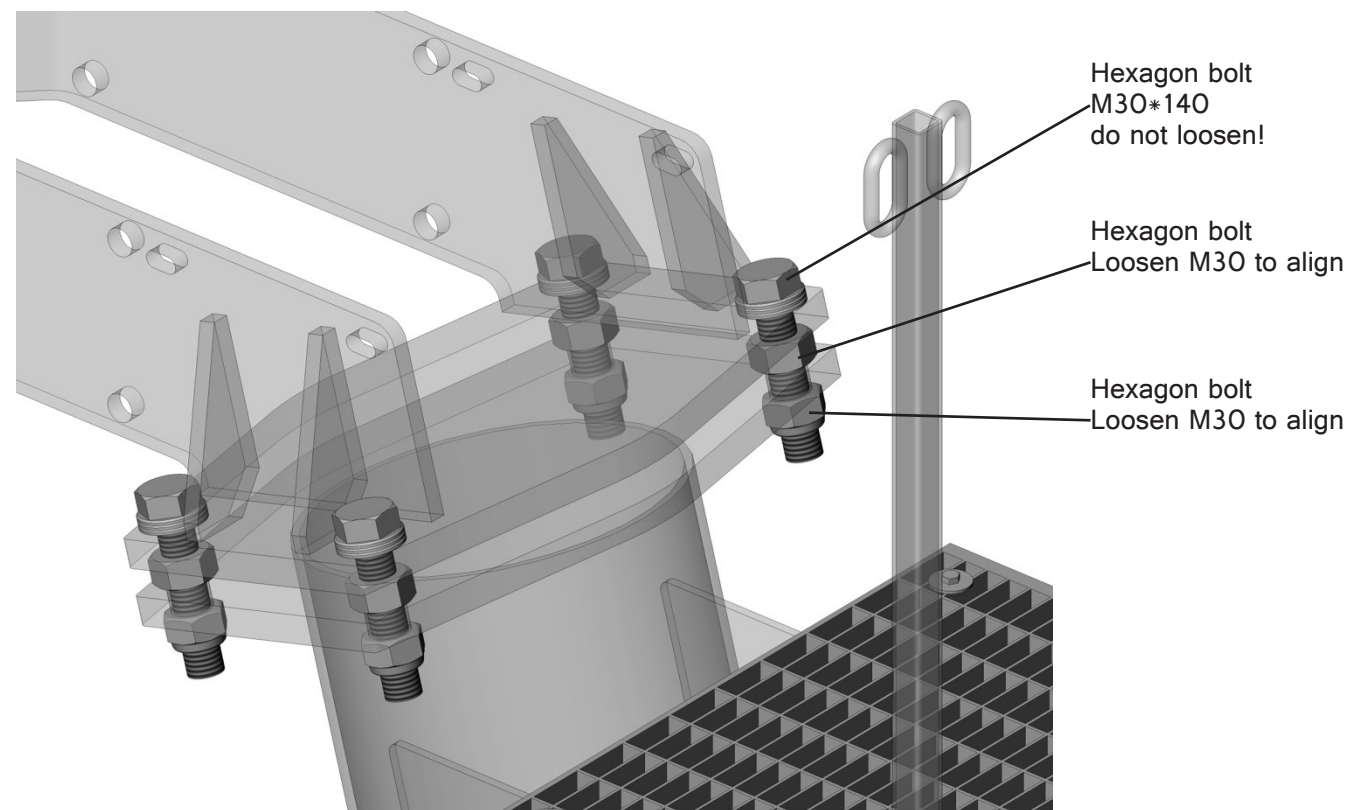
Following this, a bolt with two washers and an M-20 nut must be fitted in each hole of the connection flange and tightened with a torque wrench to 450Nm.

3.4 Earthing of the tower

After the tower has been correctly and securely bolted to the foundation as specified in chapter 3, the earth straps as described in chap. 2.2 are connected with the foot of the tower. With 3 M12x30mm bolts, M12 nuts and spring washers, the straps are bolted to the holes provided on the foot of the tower.

3.5 Aligning and lubricating the assembly mandrel

The assembly mandrel is lubricated ex works with a cold-resistant grease. If due to transportation and installation the grease no longer covers the whole surface, the mandrel must be re-greased. After the tower has been correctly and securely bolted to the foundation, the assembly mandrel must be aligned exactly perpendicular. For this the 4 M30 hex bolts at the top of the tower, between the top plate of the tower and the bottom plate of the assembly mandrel, have to be loosened a little. The inclination of the mandrel can be set with the adjusting nuts between the plates as shown in the figure below. It is important that the mandrel is exactly perpendicular, so that no jamming occurs when placing and removing the magazine with the helicopter. Afterwards the hexagon bolts can be tightened with the torque wrench (1650Nm).



Detail for alignment of assembly mandrel

3.6 Required materials and tools for erecting the tower

3.6.1 Delivered by wyszen avalanche control AG

	Article	Dimension Comments/Purpose
4 pcs	U washer	
12 pcs	HT bolts	M20 x 95 (Hex bolt with nut and 2 washers) to connect the tower foot and head piece at the flange
3 pcs	Hex bolt	Fastening the earth straps
3 pcs	Hex nut	Fastening the earth straps
3 pcs	spring washers	Fastening the earth straps
Material for the shear-relief anchor (horizontal anchor), see table 2 Foundation material		

3.6.2 Required materials and tools from the client / builder

	Article	Dimension Comments/Purpose
2 pcs	Flat / ring spanner	Width over flats 55 and 60 (for Swiss Gewi) Tightening the anchor nuts
1 pc	Flat / ring spanner	Width over flats 50 Tightening the lock nuts
2 pcs	Flat spanner	Width over flats 46 Adjusting and fixing the assembly mandrel
2 pcs	Flat / ring spanner	Width over flats 32 Fastening the flange connection between the foot and top piece of the tower
1 pc	torque wrench with socket	Width over flats 30, 32, 46 Fastening the connections
2 pcs	Flat / ring spanner	Width over flats 19 Fastening the earth straps
1 item each	Flat spanner	Width over flats 13/17 Fastening the fall-bloc safety cable
1 item each	Broom and scraper	For cleaning the base
1 pc	3 square file	for any repairing to damaged threads
1 pc	Cordless drill	Drilling bolt holes for the earth straps
1 pc	Drill ø 13 mm	Drilling bolt holes for the earth straps
1 pc	Metal cutting saw	For cutting the earth straps on the tower to length
1 pc	Side cutters	
1 pc	Pliers	
1 pc	Hammer	
1 pc	Cable shears	For shortening the fall-bloc safety cable
1 pc	Insulating tape	
1 pc	Spirit level (plumb level)	For aligning the mandrel
As required	Bandage for corrosion inhibitor	Corrosion inhibiting wrapping of the anchor head

3.7 Weights of the towers

For transportation of the tower by helicopter not only the effective weights are crucial, but also the air temperature and the height above sea-level. Precise details can be obtained from the respective helicopter transport company.

Art. no.	Design type	Total tower length	Weight individual	Weight with mandrel	Total weight incl. pedestal, mandrel and disks etc.
411.401-14 411.401-14V	Tower pedestal 5m		800kg 890kg		
411.403	Tower top piece 3m with locking door	8m	350kg	520kg	1,450 kg
411.405	Tower top piece 5m with locking door	10m	495kg	665kg	1,600 kg
411.407	Tower top piece 7m with locking door	12m	approx. 630kg	approx. 800kg	approx. 1,750 kg
411.440L-2	Tower extension 2 m	2m	approx. 225kg		

4 Recommended literature

Margreth, S.: Avalanche protection structures in avalanche fracture zones (in German) Technical guidelines as aid to implementation Environmental enforcement no. 0704. Federal Office for the Environment, WSL Swiss Federal Institute for Snow and Avalanche Research SLF Davos 2007 Edition 2009-06-04.

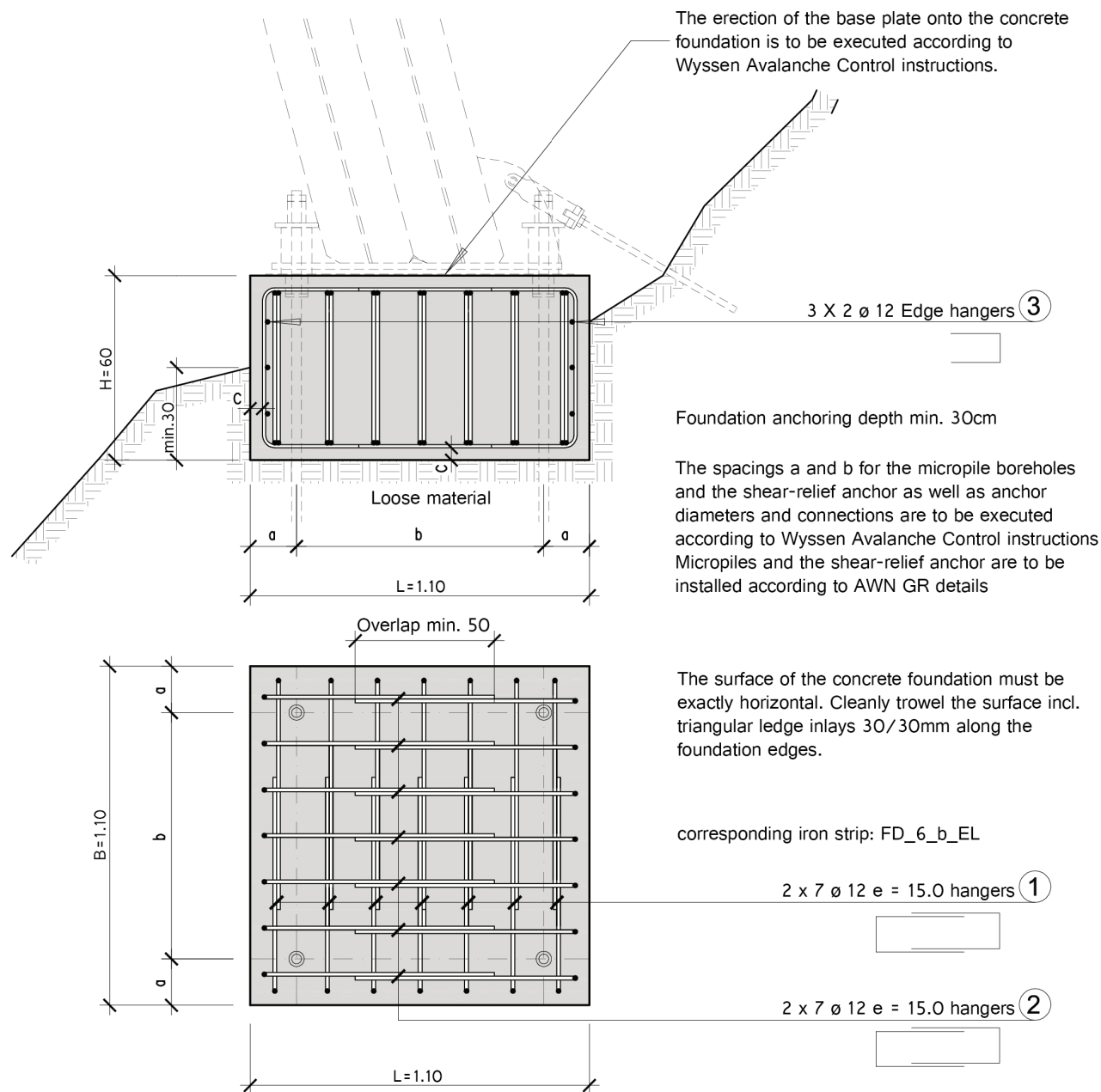
ÖNORM-Regel 24806: Permanent technical avalanche protection - dimensioning and constructive design

5 Annex

- 5.1 Locations and detail about the foundation of the planned Wyssen avalanche towers
- 5.2 Wyssen avalanche tower foundation in loose material
- 5.3 Wyssen avalanche tower foundation in rock
- 5.4 Record book for confirmation of execution

5.2 Wyssen avalanche tower foundation in loose material

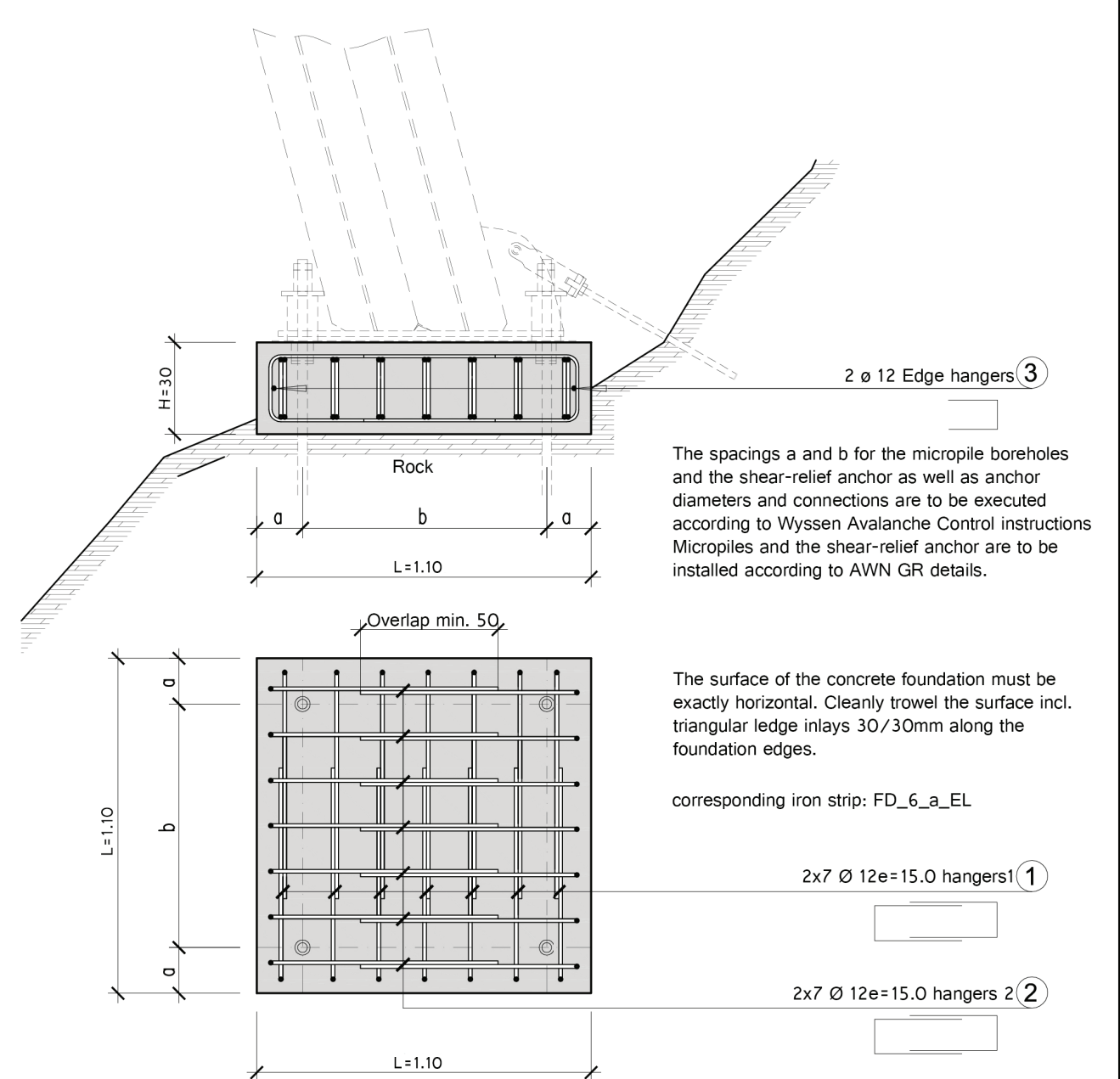
FOUNDATION OF WYSSEN AVALANCHE TOWER CAST-IN-PLACE CONCRETE FOUNDATION, TYPE LOOSE MATERIAL



Dimensioning	Type of concrete / type of formwork	Steel quality
The length of anchor L is dependent on the project-specific characteristic values of the soil. Ra,k is to be determined with pull-out trials according to SIA 267/1. Length of anchor L for micropile and shear-relief anchor according to AWN GR details. Steel quality and diameter according to details of the system supplier.	Foundation from cast-in-place concrete according to SN EN 206-1, (NPK concrete type D) C25/30, XF2 (CH)	Reinforcing steel B 500 B
	Formwork: type 2 triangular ledge inlays Reworking of the surface (high spots)	Reinforcement cover: c = 40 [mm] generally c = 50 (mm) on prepared subsoil c = 90 (mm) on unprepared subsoil

5.3 Wyssen avalanche tower foundation in rock

FOUNDATION OF WYSSEN AVALANCHE TOWER CAST-IN-PLACE CONCRETE FOUNDATION, TYPE ROCK



Dimensioning	Type of concrete / type of formwork	Steel quality
The length of anchor L is dependent on the project-specific characteristic values of the soil. Ra,k is to be determined with pull-out trials according to SIA 267/1. Length of anchor L for micropile and shear-relief anchor according to AWN GR details. Steel quality and diameter according to details of the system supplier.	Foundation from cast-in-place concrete according to SN EN 206-1, (NPK concrete type D) C25/30, XF2 (CH)	Reinforcing steel B 500 B
	Formwork: type 2 triangular ledge inlays Reworking of the surface (high spots)	Reinforcement cover: c = 40 [mm] generally c = 50 (mm) on prepared subsoil c = 90 (mm) on unprepared subsoil

5.4 Confirmation of execution of foundation and assembly

Project

Town, Postal Code

Region

Avalanche towers	Name	Anchor length	Anchor inclination	Anchor capacity

Confirmation

- The construction of the foundation and the assembly of the Wyssen avalanche tower were complied with according to
- ✘ State of the Art
 - ✘ Manufacturer’s guidelines as described in the "Foundation Instructions of the Wyssen avalanche tower LS12-5“.

The prescribed specifications in the instructions can be met by the foundation.

Name and address of the Company

Signature, Company Stamp

Place, Date



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www.wyssen.com



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