SENVION
wind energy solutions

Company: Senvion GmbH Überseering 10 22297 Hamburg, Germany **Original document:** German **Translator:** Service provider **Internal approval** **Prepared by:** [redacted] **Checked by:** [redacted] [redacted] **Approved by:** [redacted] **Valid from:** 2015-09-11 **Document number:** V-1.1-GP.00.10-A-L-EN **Pages:** 32	**Installation Management, Methods & Tools** # Specification for the transportation, transportation routes, other access paths, and crane pads WTG SENVION MM82/92/100/3.2M114/3.4M104/3.4M114 (NES)/3.0M122/3.2M122 NES Instruction **Place:** Büdelsdorf
Authorized recipients: ☑ **internal** ☑ **external** **Confidentiality level:** ☑ **general** ☐ **confidential** ☐ **strictly confidential**	

0 General

0.1 Change history

Version	Short	Date
A	First edition	-
B	Content and layout revised	2008-05-06
C	Bilingual	2008-06-16
D	Address and linked documents updated	2008-11-10
E	Design of access paths and crane pad	2010-09-01
F	Dimension table for Senvion MM100; various text passages; Annex I to X	2011-06-20
G	Was not translated	
H	Adaptation to English revision H Various text passages	2012-07-18
I	Change of the dimension of the crane pad on page 38 Omission of section 4.2 to 4.5 Omission of Annex VIII to X	2012-09-12
J	Content and layout revised 3.0M122 included Advance delivery included	2014-08-18
K	Included 3.4M114. Layout revised.	2014-12-17
L	Included 3.2M122 NES and 3.4M114 NES. Removed related documents in §3. Removed maximum force on crane support and on tip of chain in §5.3.2. Various text passages.	2015-09-11

Changes are marked gray within the document

0.2 Table of Contents

0.3 List of figures

1 Goal and purpose

The present specification of the transport routes and crane pads is a binding agreement between the parties regarding the precise design of these assembly sections. Both parties accept this agreement as a contractual component.

The precise implementation of the requirements/dimensions determined in these specifications ensures that the installation of the wind turbine can take place safely and at the cost agreed to in the contract. Failure to comply may result in higher costs and expenses, and in particularly severe cases occupational safety can be compromised during installation.

As a result, the following is agreed to:

- If the requirements/dimensions determined in this specification are adhered to, installation of the wind turbines at the costs, quality level, and deadlines laid down in the contract shall be undertaken as a binding commitment.

- If the requirements/dimensions determined in this specification are not complied with, an installation is generally still possible. It will, however, require an onsite inspection as well as a project-specific approval.

2 Scope

This specification defines the prerequisites, ambient conditions, equipment and auxiliary means required for the flawless delivery, storage and installation. Compliance with them ensures a smooth process from the point of view of logistics, technical erection and occupational safety. It is also applicable to the older wind turbines MD70/77 for service and replacement of major components.

Senvion recommends taking these specifications into consideration during the planning of the construction site and/or the construction roads. This frequently allows an ideal solution for both sides to be found.

Any deviations from this document can only be approved in coordination with the project logistics and construction site management of Senvion.

This document is applicable within the EU and serves globally as the basis for wind turbine projects with logistics and erection by Senvion.

3 Related documents

Document title	Document number
-	-

4 Terms and abbreviations

Name	Explanation
PM	Projectmanagement
Plate load test	Test to determine the bearing capacity of soils and materials. The implementation is defined in the DIN-Norm DIN 18134 Soil – Testing procedures and testing equipment – plate load test
Proctor density	Highest achievable density of a soil under defined compacting which can be set in the standardized test (proctor test according to DIN 18127) with optimal water content
E_{v1}	Deformation modulus (MN/m^2) – Modulus obtained in the 1st load cycle, which can be achieved with the plate load test
E_{v2}	Deformation modulus (MN/m^2) – Modulus obtained in the 2nd load cycle, which can be achieved with the plate load test
E_{v2}/E_{v1}	Compression ratio

5 Geometry and weights

5.1 Access road

5.1.1 Vehicle dimensions

Max. truck-trailer length (rotor blade transport)	Approx. 70 m
Structural clearance – min. height	5.5 m
Structural clearance – min. width	5.5 m (6.5 for hybrid towers)
Usable road width	4.5 m

5.1.2 Longitudinal radii (peak and trough loading radius)

MM82, MM92	≥ 200 m
MM100, 3.2M, 3.4M	≥ 400 m
3.0M	≥ 600 m

5.1.3 Longitudinal inclination

Normal structure (gravel road)	≤7 %
Bonded face sheet (only in consultation with the project management of Senvion can a deviation be agreed)	7≥12 %
Bonded face sheet, additional special transportation technology	>12 %
Ground clearance of the vehicles	≥10–15 cm

In case the above-mentioned inclinations were exceeded, it is possible to develop a project specific solution in consultation with the Senvion project management/logistics. The resulting additional costs arising from this, e.g. special arrangements for towing vehicles or reloading components to other transport vehicles, will be invoiced to the contractually responsible parties.

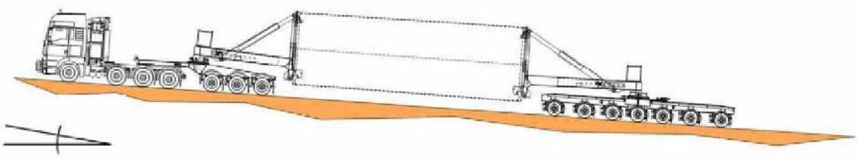


Figure 1: Longitudinal inclination (illustrative purpose)

5.1.4 Transverse inclination

Lateral inclination of the road with a straight face sheet	≤2 %
Lateral inclination for construction of the face sheet as a roof profile from the middle of the road to the outer edge	≤3 %
Slope angle	1:2

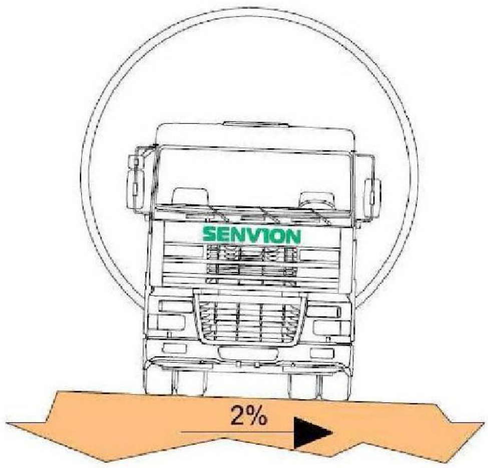


Figure 2: Transversal inclination (illustrative purpose)

5.1.5 Temporary fixing for funnel-shaped entrance road

In many cases it is sufficient to temporarily expand the funnel-shaped entrance in the area of the delivery roads. Steel plates and the like or a temporary gravel expansion can serve this purpose. After completion of construction, they can be stripped down to a radius of curvature of 15 m. In case of replacement of major components, these surfaces must again be appropriately prepared by the buyer.

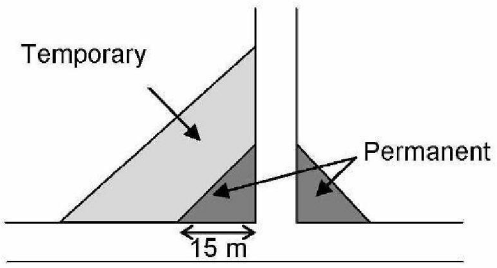
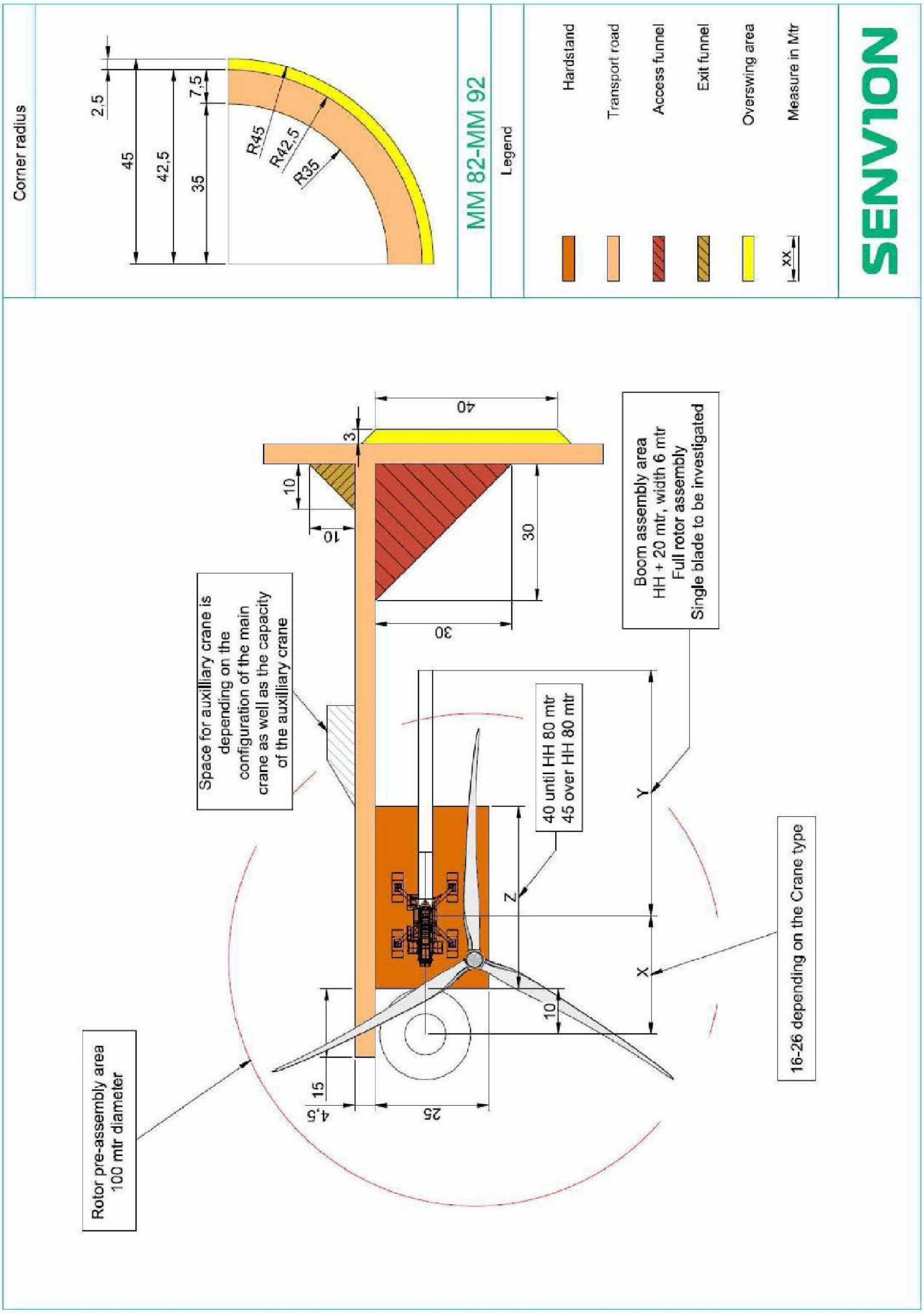


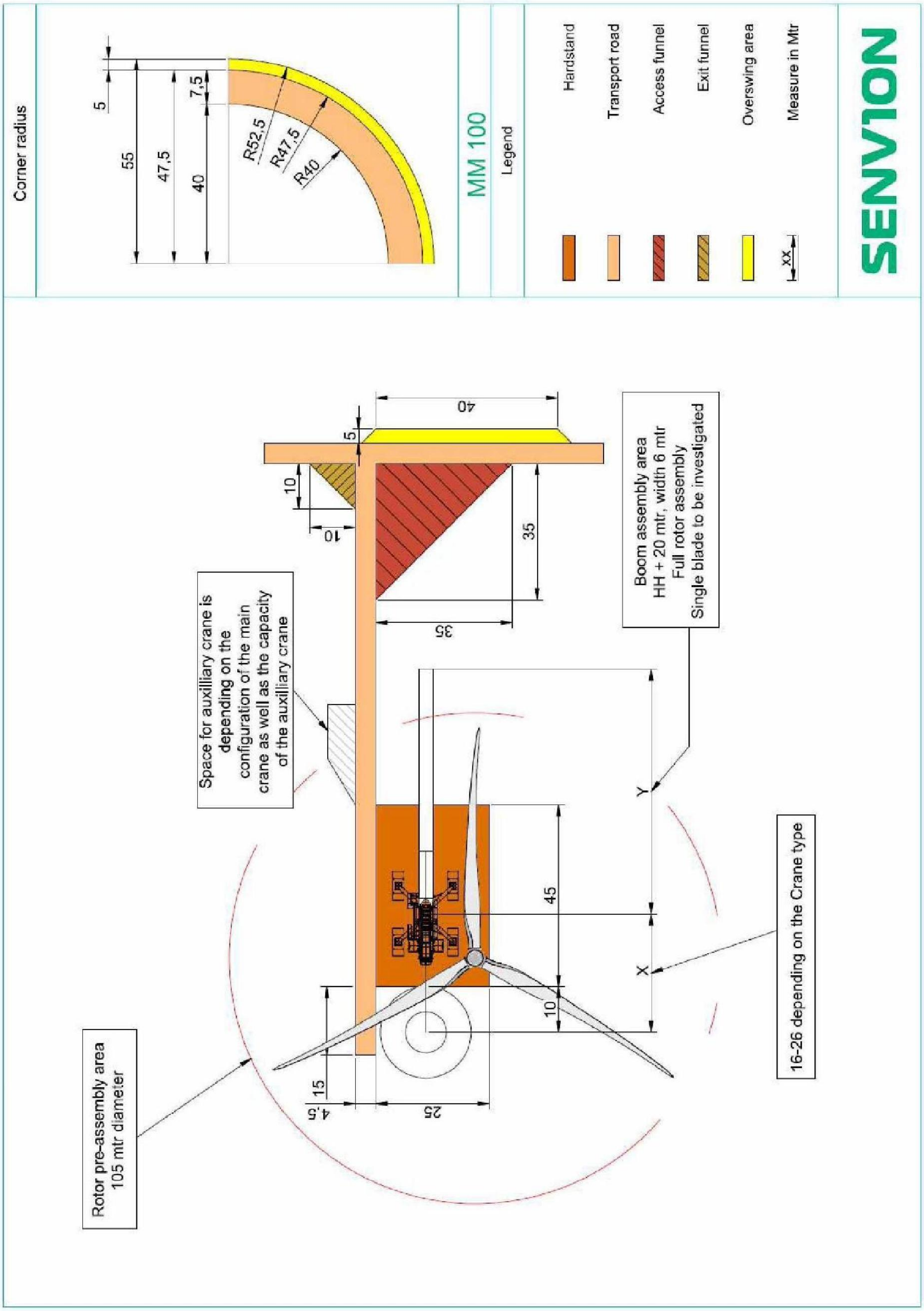
Figure 3: Temporary and permanent funnel shaped entrances (illustrative purpose)

5.2 Crane pad

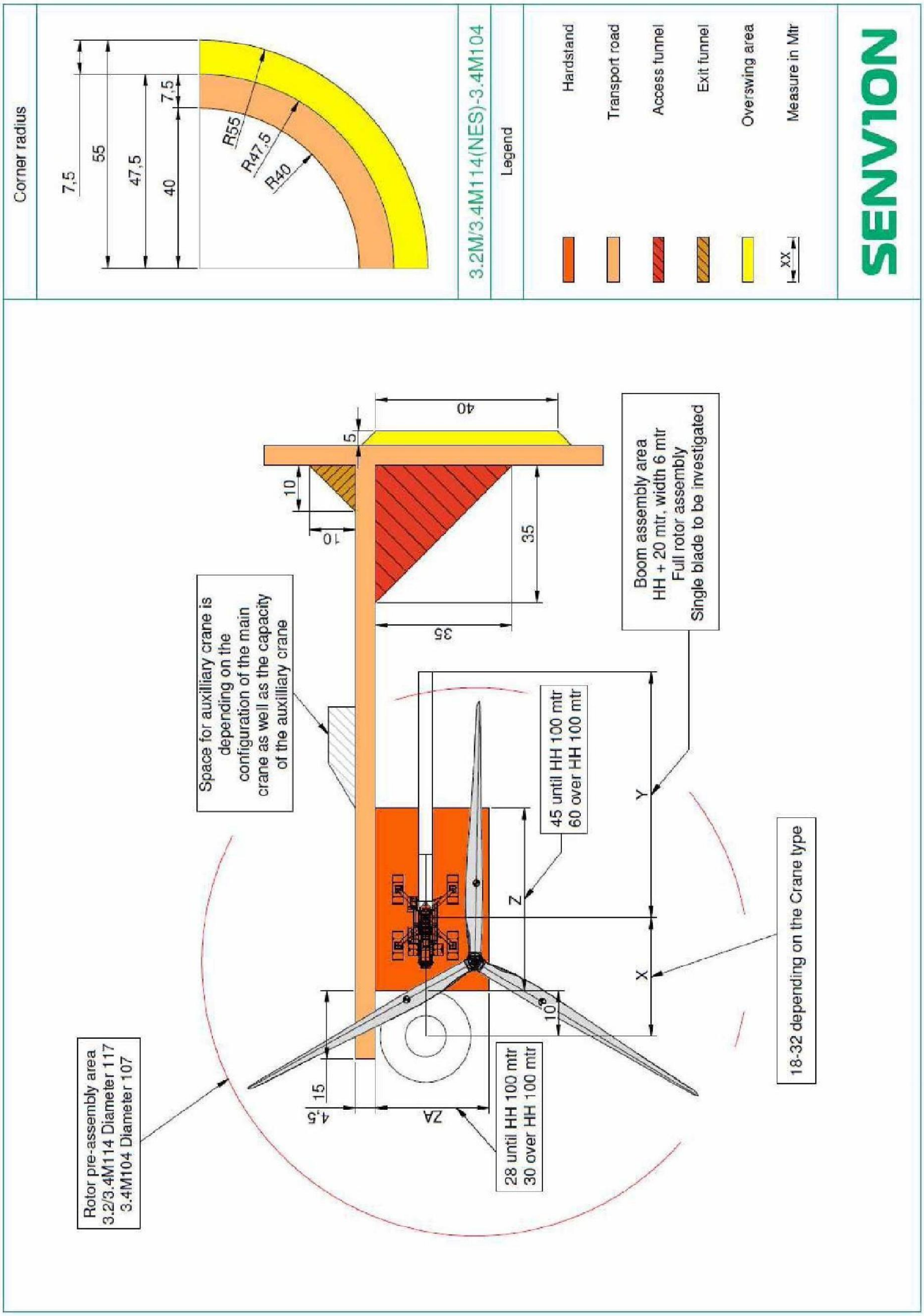
5.2.1 MM82/92



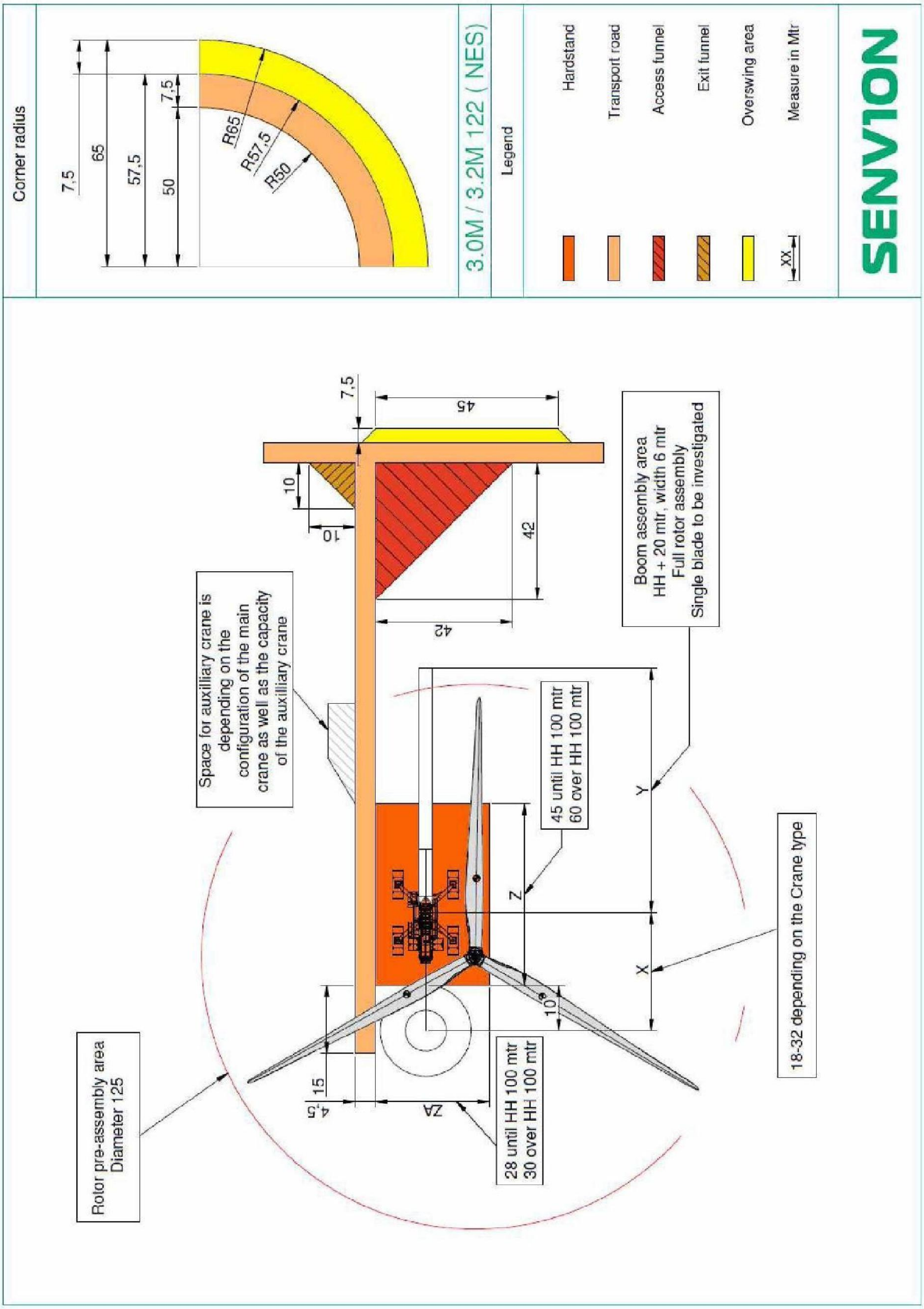
5.2.2 MM100


Corner radius
5
55
47,5
7,5
40
R52,5
R47,5
R40
MM 100
Legend
Hardstand
Transport road
Access funnel
Exit funnel
Overswing area
Measure in Mtr
xx
SENVION
40
5
10
10
35
35
Boom assembly area
HH + 20 mtr, width 6 mtr
Full rotor assembly
Single blade to be investigated
Space for auxilliary crane is depending on the configuration of the main crane as well as the capacity of the auxilliary crane
Y
X
45
10
16-26 depending on the Crane type
15
4,5
25
Rotor pre-assembly area
105 mtr diameter

5.2.3 3.2M114 / 3.4M114 (NES) /3.4M104



5.2.4 3.0M122/3.2M122 NES



5.2.5 Storage spaces for major components

Senvion prefers a construction concept with advance delivery of major components. The required level storage spaces around the crane pad are to be provided to Senvion temporarily for constructing the wind turbine. Strips approximately 15 m wide are to be provided adjacent to the crane pad. In the course of preparation of the project-specific delivery and construction concept, it is decided which areas will be used and what kind of attachment is required for these areas.

Alternatively, in case adjacent areas were not available due to restrictions of the terrain, a temporary area should be foreseen as close as possible to the location with sufficient space for unloading and reloading the components. These additional costs are to be borne by the buyer.

In the markets served by Senvion Deutschland Gmbh, the advance delivery concept is planned by default; if this is not possible, additional costs are to be borne by the buyer.

Different examples are shown below:

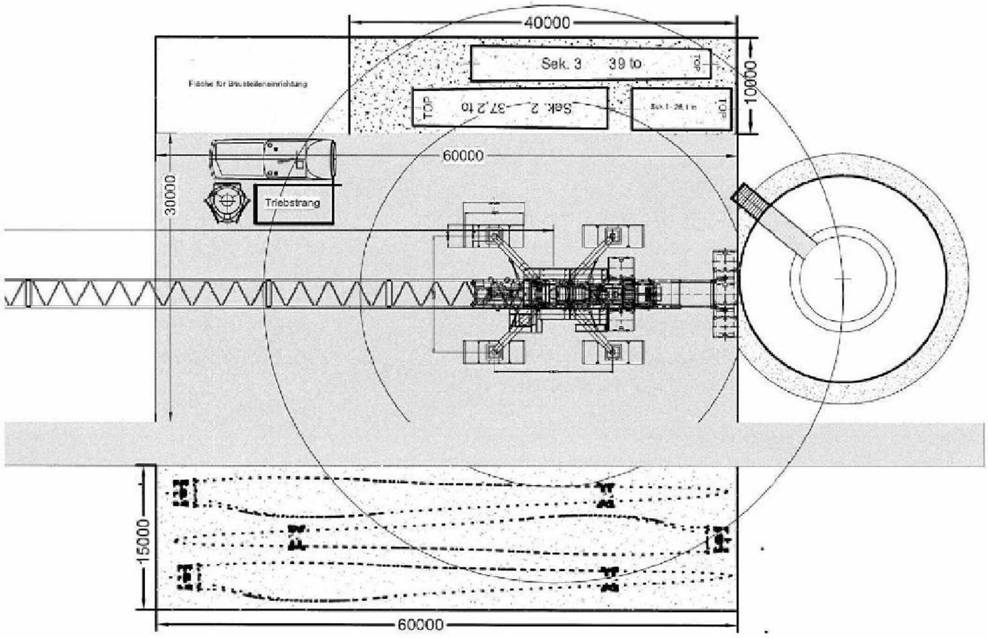


Figure 4: Example of advance delivery for 3.2/3.4M HH 123-143 m

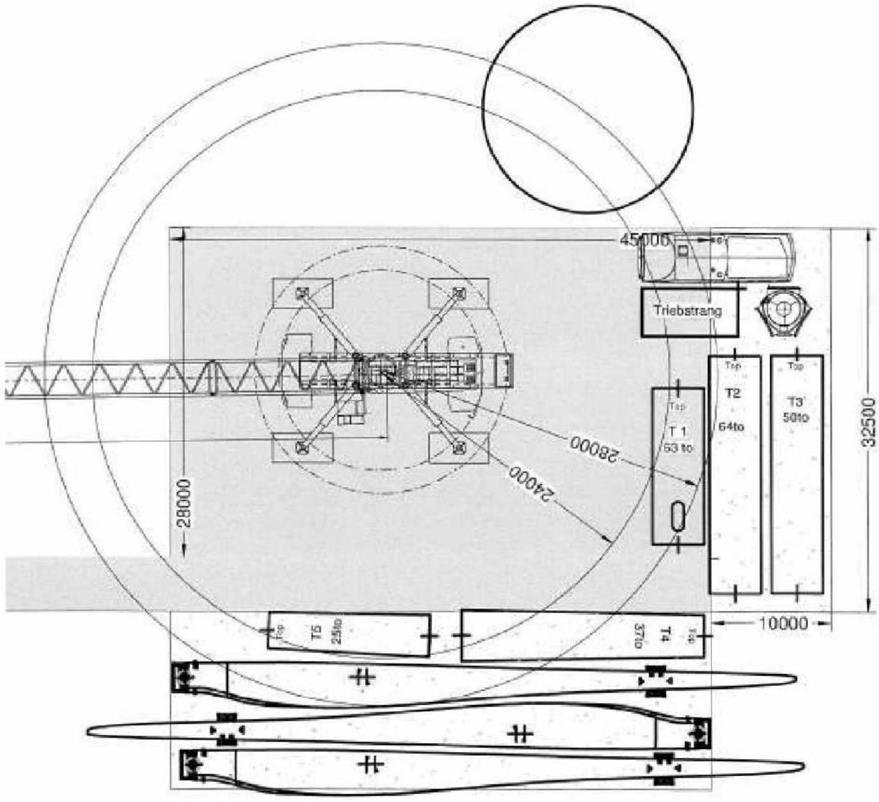


Figure 5: Example of advance delivery for 3.2/3.4M HH 93m

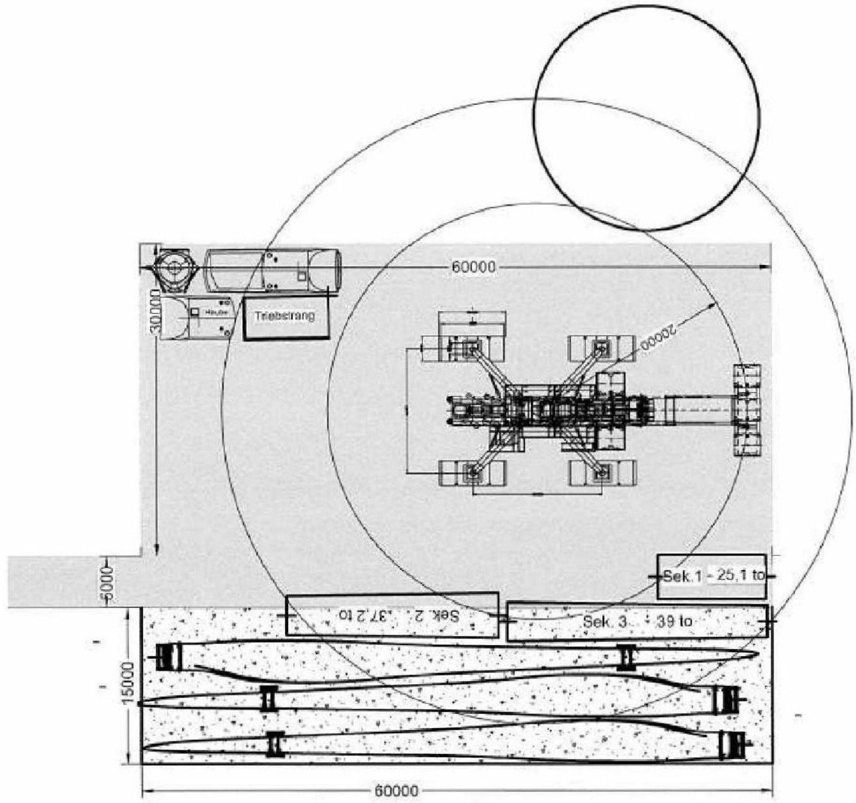


Figure 6: Example of advance delivery for 3.2/3.4M HH 123-143 (with super lift)

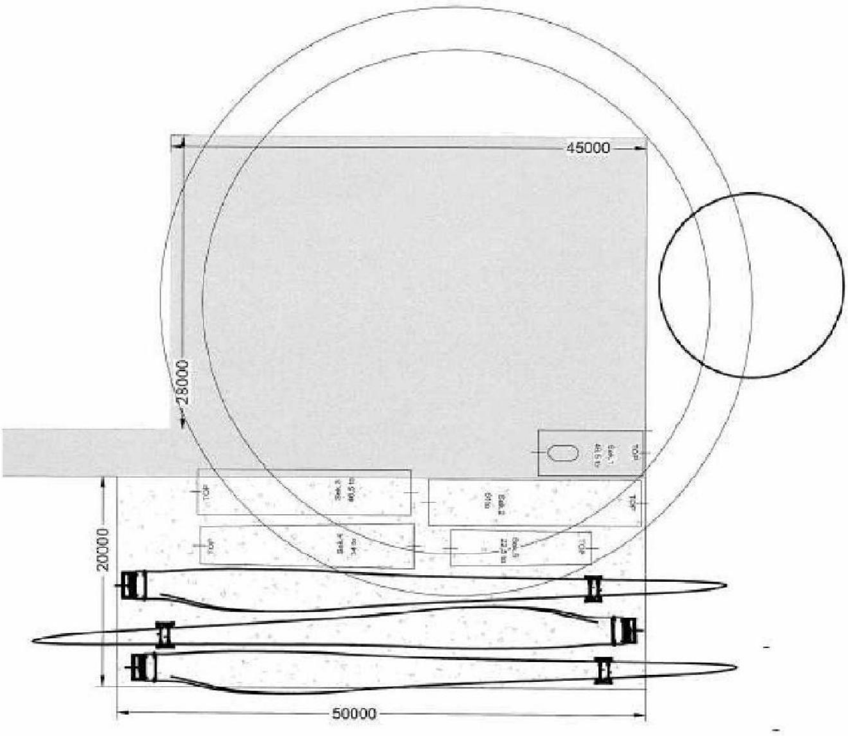


Figure 7: Example of advance delivery for 3.4M HH 93 m

5.2.6 Areas available for setting up construction equipment

For office and material containers, sanitary facilities, and the like, an area of about 12x20 m adjacent to each crane pad is required. Additional areas in the vicinity of the crane pad will be needed for parking cars.

These areas may need to be secured in an appropriate manner in consultation with the Senvion Project Management.

5.2.7 Crane pad inclination and dewatering

Allowed inclination (mobile and crawler cranes)	0-0,3%

It must be ensured that rainwater is drained as quickly as possible from the emplacement and cannot accumulate in any area. The proposed surface layer will help to ensure that this is ensured for the intended service life of the crane pads (gravel material or similar). Further measures for draining the rainwater may be required (filter membrane, drainage, pump sump). The load-bearing capacity of the crane pad must be ensured for both dry and wet conditions.

5.3 Soil Parameters

5.3.1 Access road

E_{v2} (upper edge of the subsurface)	≥ 45 MN/m²
E_{v2} (upper edge of the support layer)	≥ 80 MN/m²
E_{v2}/E_{v1} (upper edge of the support layer)	≤ 2.5

Proctor density	100 %
Number from static plate load tests	≥ 1 for every 100 m of construction road (in different positions of the road width: left side, center and right side)
Maximum axle load for transports	12.5 t
Maximum crane axle load	15.0 t
Maximum vehicle weight	140.0 t

5.3.2 Crane pad

E_{v2} (upper edge of the support layer)	≥ 100 MN/m²
E_{v2}/E_{v1} (upper edge of the support layer)	≤ 2.5
Proctor density	100 %
Maximum surface pressure With crawler cranes	200 kN/m² 240 kN/m²
Number from static plate load tests	≥ 3 for each emplacement
Maximum weight of assembled crane (mobile or crawler crane)	660.0 t

The load-bearing capacity of roads and crane pads must be checked using static plate load tests in accordance with DIN 18134 or the corresponding country-specific standard.

5.4 Required geotechnical evidence of the stability of access paths and emplacements

At least 1 stability / ground failure certification with certification of 2-fold bearing capacity for each 10 emplacements (for the most critical situation)
At least 1 stability certification (certification of the bearing capacity) for especially endangered areas, such as construction roads or crane locations with steep slopes

The expected settlement must be determined as part of the ground failure certification. Maximum settlement under the crane load may not exceed 3 cm.

For larger values special measures are required. This calculation on the basis of the planned crane pad structure must be submitted to Senvion prior to implementation.

6 Annex I – General information / requirements

6.1 Planning

The planning of transport routes and crane pads is of significant importance for a cost-effective and safe construction sequence.

In addition to purely ensuring access to the individual locations for the heavy goods vehicles used, it is essential that the various transport operations (e.g. construction vehicles for laying the foundation, transport vehicles for wind turbine components, the vehicles of the site manager and the customer) work optimally next to each other and do not obstruct one another.

It must also be ensured that the various transport vehicles carrying wind turbine components can travel at the same time on the site roads and that there are suitable passing and turning areas.

It is therefore agreed that every construction site be subject to final approval in good time and no later than 4 weeks prior to commencing work on the transport routes and crane pads. Suggestions made at this approval meeting on required parking spaces, passing and turning areas, and special traffic routing agreements must be included in the construction preparation if technically possible.

6.2 Vehicles

The following vehicle types, frequencies, and loads are typical for a construction site and are to be taken into consideration in the planning:

a) Foundation construction and concrete tower:

MM-59 to 100 m:	approx. 45 concrete vehicles as well as various delivery vehicles for construction steel, tower foundation section, casings, etc.
3.xM-80/100 m:	up to 80 concrete vehicles as well as various delivery vehicles for construction steel, tower foundation section, casings, etc.
3.xM-128 m:	up to 100 concrete vehicles as well as various delivery vehicles for construction steel, tower foundation section, casings, and prefabricated tower elements, etc.

b) Assembly and disassembly of the main crane:

MM-59 up to 100 m:	up to approx. 24 vehicles
3.xM-80/100 m:	up to approx. 28 vehicles
3.xM-143 m:	up to approx. 50 vehicles

c) Transport Vehicles for Wind Turbine Components:

MM-59 to 100 m:	approx. 8–11 heavy goods vehicles
3.xM-80/100 m:	approx. 10–13 heavy goods vehicles
3.xM-143 m:	up to approx. 60 heavy goods vehicles

d) Additional transport will be conducted with vehicles from experts, site managers, erection teams, e-suppliers, etc.

6.3 Securing loads

All primary components except for the tower sections are marked with simple sketches indicating the main dimensions and the center of gravity.

The exact anchor point and the recommended attachment material is defined in a separate specification.

For securing the loads, in each case the applicable statutory directives of the country through which the transport moves must be observed.

6.4 Loading, unloading, and handling wind turbine components

Each wind turbine component is a complex system which reacts sensitively to improper handling. The components are therefore to be handled with great care during all loading and unloading as well as during handling and stowing.

Cleanliness when entering the wind turbines and/or their components must be strictly observed. Entering the wind turbines and/or their components with unclean work clothing (clothes, gloves, boots, etc.) is not permitted.

During all handling and storage, especially in harbors, it must be ensured that the turbines remain sealed with the existing protective film and/or are resealed if handling has occurred so that no rain and dirt can penetrate. The equipment is to be stored in such a manner that it is not unnecessarily soiled.

The personnel employed in these tasks, such as signalmen, longshoremen, storage personnel, etc., must be instructed before loading/unloading and storage. Many components installed in a wind turbine respond sensitively to grease, oil, aggressive liquids or mechanical stress.

Only the attachment material approved by Senvion may be used. The attachment material must have been tested and approved and must not show any signs of damage or contamination. The use of chains inside the major components is not allowed under any circumstances.

The loading and hoisting instructions “M-2.1-GP.00.02-A” in the respectively valid version must be complied with for the handling/hoisting of components.

6.5 Packaging and storage

The packaging must protect the wind turbine components against the prevalent ambient conditions during transport and storage.

The equipment is generally prepared for storage for up to approx. 8 weeks at the factory. The manufacturer must be consulted if the wind turbines or their components are to be stored for an extended period of time or in the event of difficult climatic conditions.

6.6 Specific information regarding individual turbine components

6.6.1 Tower sections

The tower sections must be sealed using tarpaulin on the flange openings in order to avoid dirt and water penetration. During storage and transport it must be ensured that there is no direct contact of the tower wall with rough and sharp-edged objects, the ground and obstacles which might cause damage to the varnish coat.

If tower components are loaded and transported with transport adapters, ensure that care is taken while docking the transport vehicles to the tower components in order to avoid damaging the tower flange. Furthermore, ensure that the transport tarps are firmly tied and sealed so that no dirt and water can penetrate the tower segment during transport.

The selected transport height must be checked before commencing a journey and adapted to the respective route conditions. If needed, a second individual must act as marshaller when passing viaducts and narrow passages.

6.6.2 Rotor blades

During storage and transport it must be ensured that there is no direct contact of the blade surface with rough and sharp-edged objects and obstacles which might cause damage to the blade and its face sheet.

During road haulage it must be ensured that the blade is sufficiently protected against all vibrations, e.g. using felt or carpet to protect and support the blade on the truck loading area.

6.6.3 Rotor hub

For the transport of the rotor hub it must be ensured that all tarps are well attached and tied. The cover tarpaulin and the cover of the rotor hub must be present and completely bolted to avoid "flying off" during transport and to prevent rain and dirty water from entering.

6.6.4 Nacelle

After loading, the nacelle must be sealed with tarpaulin on its front to prevent dirty water and dust from entering. The hatch in the roof of the nacelle must be sealed in such a way that it cannot come loose due to the vibrations or the effect of the relative wind during transport. When unloading the nacelle it must also be observed that the nacelle must only be entered with shoe covers and clean working gloves. The nacelle roof must be fully closed and secured after each handling.

6.6.5 Particularities of the 3.XM

- Nacelle hood

The nacelle hood of the 3 XM is disassembled for transport and transported on the center lines of the nacelle vehicle. The hood is to be placed on squared timber if stored at the construction site so that it is not soiled or damaged due to contact with the ground.

- Drive train

The drive train may only be transported on the transport frames provided. It is packed in shrink wrap to protect it from soiling. The foil must be inspected for damage before storage.

- Accessories

The accessories of the turbines will be transported in 40-foot "open top" containers. In the event of extended storage periods, ensure that no rainwater collects on the tarps. The tarps can also be propped up from below to ensure that the rainwater will drain.

A packing list of the respective turbines is available from Senvion upon request.

7 Annex II - Transport

7.1 Public roads

The following applies to public roads:

The precise routing and scheduled delivery date are only confirmed after a heavy goods transport approval has been obtained and the escorting police have issued an escort confirmation. That means that routing measures (dismantling, bridging of traffic islands, lamps, traffic signs, guard rails etc.) may be required on short notice. Routing measures could lead to additional costs and must be planned in a timely manner to avoid delays in the planned delivery.

In bad weather (ice, snow, fog), transport delays may occur, because the heavy goods transports are subject to authority restrictions and regulations. When road conditions are difficult, continuation of the journey can be prohibited.

There may also be unpredictable delays to the delivery due to increased traffic on public roads and bottlenecks during the approval process by the respective authorities and the police.

7.2 Parking on public roads

The following applies in general: The heavy goods transport authorization incl. police escort ends at the construction site entrance, i.e. when leaving the public and usable roads. Outward and return transport journeys to the construction site using public roads are fixed by the legislator in the form of prescribed routes.

Parking the transport vehicles in public traffic areas in front of the construction site entrance is only possible in individual and authorized exceptional cases, i.e. sufficient parking space and adequate passing and turning facilities must be provided within the construction site for the transport vehicles.

If the vehicles cannot be parked within the construction site, the public traffic area must be sealed off, a process which must be applied for by the responsible contractual party at the local authorities prior to starting construction. Approval for this purpose is not enforceable.

The parking space must be adequately secured ("No entry" signs, lighting) to prevent impeding other road users or exposing them to unexpected danger.

7.3 Construction site entrance

The construction site entrance starts at the end of the public roads which are usable by the transport vehicles.

The heavy goods transport approval applies to both the laden and unladen journeys, i.e. the empty transport vehicles leave the construction site on the same road on which they arrived.

If the vehicles cannot turn on the construction site, the construction site entry must be designed as a positing system, so that the transport vehicles can use the same entrance moving in and out.

The size of the curve radius to the construction site exit is based on the length of the longest unladen vehicle that will leave the construction site. In general, the determining factor is the transport vehicle for the nacelle or the boiler bridges of the tower section transports.

There must be no obstacles in the inside and outside of curves on path level. The dimensions of the curve radii prescribed in the individual drawings must be adhered to. The entry and exit positing system to be observed must be constructed in accordance with the drawing.

The point of transfer of the responsibility for the road construction changes must be determined with Senvion on a project-specific basis. The basis for this is the feasibility study created by Senvion.

7.4 Construction site roads

7.4.1 Requirements

During the erection and the whole operating time of the wind turbine it must be ensured that the wind turbine can be accessed by cranes and transport vehicles at any time for service calls or repair work. The roads, paths, bridges, etc., must always be designed and approved for passage by heavy goods vehicles with an axle load of up to 12.5 tons and a total weight of 140 tons.

Rural and forestry roads may have trenches or bridges which are unsuitable for the ultimate loads. Load reinforcements or a parallel passage via mobile bridges must be possible here.

The surface of the construction road must be of a type that does not cause damage to tires and does not permit any serious road grooves or saponification.

All layers must be machine compacted in layers. The relevant directives of earthwork apply to all earthwork.

The accumulation of rainwater on the surface of the path must be prevented by suitable measures (such as depressions on the side of the access paths rapidly draining the water), or by installing drainage alongside the road. The drainage of the ground level (transverse inclination, drainage line, etc.) is required to ensure that the ground level does not subsequently soften through penetration of surface water softening, leading to a reduction in the load-bearing capacity.

The requirements for soil parameters are named in 5.3.1.

7.4.2 Requirements for gradients

The requirements are named in 5.1.3 and 5.1.4.

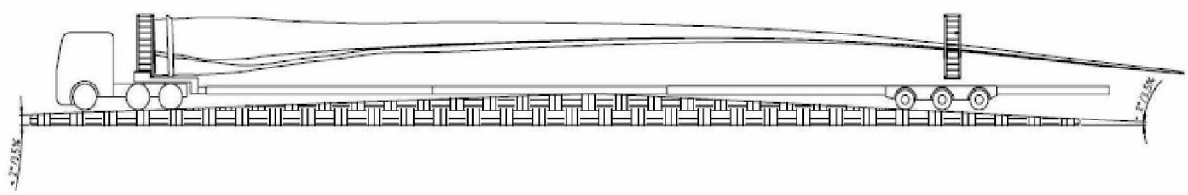


Figure 8: Transport vehicle with longitudinal inclination (illustrative purpose)

7.4.3 Recommendation

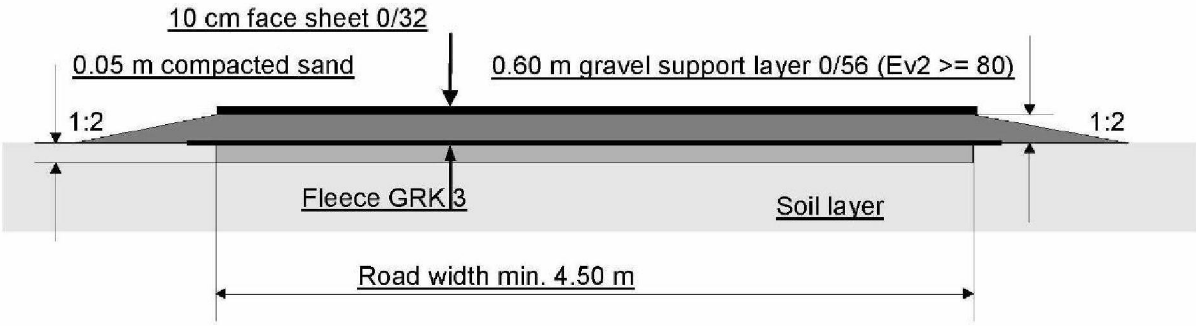


Figure 9: Schematic design of access paths

For the construction of roads, the support layer is constructed in gravel (with a grain of 0/56 mm grade, see grading curve range in Annex II, layer thickness dependent on the substrate in order to achieve the required E_{V2} module) on a compacted sand substrate (approx. 0.05 m) Prior to applying the support layer, the humus top soil must be removed completely and soaked areas in the soil layer must be stabilized accordingly (see below).

The material for the face sheet (layer thickness 10 cm) may have a maximum grain size of 32 mm (see grain range in Annex IV – Grain distribution curves).

The material must be graded in accordance with the appendices, i.e. there must be sufficient fine material. Natural gravel is problematic during the wetter seasons, because it tends to absorb water and saponify. This does not include broken granite.

To prevent silting and displacement, a tear-proof fleece of robustness category GRK 3 (required push-through force FP.5 % ≥ 2.5 kN; required mass per surface unit mA, 5 % ≥ 250 g/m²) is required between the foundation (sand) and the support layer (gravel 0/56).

The values specified may differ depending on the ground characteristics at the location .

If the substrate conditions are unfavorable, it is not possible to achieve the required modulus of deformation of $E_{v2} \geq 80$ MN/m2 on the surface of the support layer at a layer thickness of 60 cm. The prerequisite is an E_{v2} value of the untreated substrate of a minimum of 45 MN/m². In this case appropriate improvement measures (raising the soil layer, stabilizing the ground with hydraulic bonding agents, laying a geogrid with fleece etc.) must be carried out.

Turf, bog and clay soils must be considered separately; here the permitted soil pressure according to DIN 1054 must be set to 0 MN/sqm. For this reason, special measures must be provided and checked and approved by the soil expert.

The precise design with which the required values can be achieved ($E_{v2} \geq 80$ MN/m2 and $E_{v2} / E_{v1} \leq 2.5$) must therefore already be determined in advance using test fields. The result must be submitted to Senvion prior to the actual implementation.

Deviations from the above-mentioned specification are only permitted in consultation with the project manager and possibly a soil expert.

Especially during the construction or delivery phase of the major components of the wind turbine, a firm and level access path must be available and secured. Potholes,

accumulations, ruts, etc., must be repaired prior to the next transport. The necessary measures are mutually agreed with the site manager.

If, due to improper or poor building material in the face sheet of the construction road, damage to tires or other vehicle parts occurs, in the event of damage the compensation claims of the forwarder or the crane operator will be payable by the service provider. The same applies for damage to the major components or delays in the construction process.

Heavy goods vehicles are designed for paved roads – they are not off-road vehicles.

7.4.4 Carrying out the construction site acceptance

Design of transport routes and crane pads contrary to the specification:

If the requirements/dimensions determined in this specification could not be complied with in whole or in part, an exact, project-specific inspection of the installation location must take place on site. This will generally be conducted by our specialists from the project logistics and/or construction site management departments.

After a successful on-site inspection, the customer will be provided with a written statement in a timely manner stating whether and within which framework conditions an installation can take place. If an on-site inspection has been conducted and a written statement has been submitted, this will replace the general specification provided here.

7.5 Vehicle delivery and parking facilities

The contractually responsible party must ensure that all components of the wind turbine can arrive and be parked on the construction site in accordance with the customs and legal regulations of the country.

Suggestions for parking the vehicles:

- Unused assembly areas at the wind farm.
- Temporary erection of a warehouse/unloading area near the construction site.
- Temporary erection of a parking strip alongside the access road.

In this case, "Truck way" and/or "RolaTrac" plates can be used as substrate.

A short approach distance for vehicles from the parking area to the erection area of the wind turbines and a direct exit for the unladen vehicle which does not obstruct the entry of the next component transport is essential to ensure the smooth flow of materials during the assembly process.

Senvion project management illustrates this in a logistics concept.

7.6 Unloading the vehicles

The wearing of protective clothing is mandatory on all Senvion construction sites. Safety helmets, safety boots, protective gloves, protective workwear must be donned prior to unloading. The instructions given by the construction site manager must be observed. Violations will be punished with immediate dismissal from the construction site.

The components are delivered in the direction required by the crane. After unloading, a turning opportunity near the crane pad or a separate exit route from the construction site must be available.

Reversing the component transports in the loaded condition is only permitted after consultation with the Senvion project manager and the haulage companies involved.

If the assembly area has to be entered in reverse, this is never permitted without consultation with and approval by the freight carrier, the crane company and the project management/logistics. The resulting additional costs, such as an extension of the access path by up to 25 m past the assembly area and the foundation, must be borne by the responsible party (see the drawing of assembly areas in 5.2).

7.7 Storage facilities

7.7.1 Storage areas

For the advance delivery concept, it is necessary to provide storage areas for the major components on the side of the crane pads. Examples are shown under 5.2.5.

7.7.2 Global transport

This manual is the basis for creating parking spaces and access paths. However, these must be adjusted to the country-specific elements and requirements. Among other things, limited axle loads and other dimensions of the transport vehicles must be taken into account.

In some countries it might be useful and necessary to include the transport technology in the shipment from Europe. This must therefore be coordinated and a logistics concept created well in advance (with the project management/logistics prior to signing the contract).

8 Annex III – Erection of the wind turbine

8.1 Geometric requirements for the erection of the crane technology

For the erection of the wind turbine, lattice mast or telescopic cranes are used in the necessary configuration depending on the available crane technology.

When using lattice mast cranes (crawler or mobile crane) it must always be ensured that the crane boom can be placed down in its full length, dependent on the wind turbine height (up to 148 m) and assembled and disassembled by way of the auxiliary crane. The assembly and disassembly of the boom can only be carried out in the opposite axis of the tower and crane slew ring or at a 90° angle to it.

The provided space must be flat and without obstacles. The minimum length of the area is the rotor blade height +20 m, measured from the slew ring center of the crane.

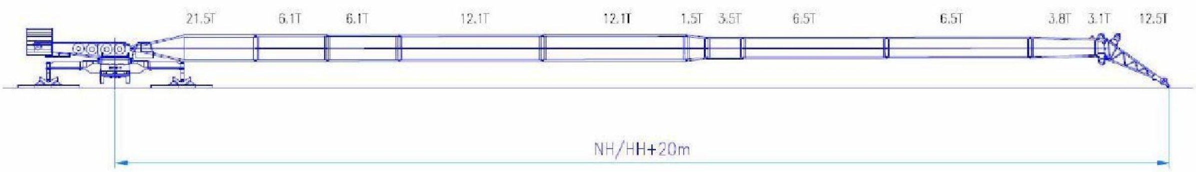


Figure 10: Minimum length of the area for crane boom montage (illustrative purpose)

The assembly and placing of the boom should be planned and carried out parallel to any other required access path. For the assembly / disassembly of the lattice mast, two or three parking spaces for the auxiliary crane must be provided depending on the crane technology used.

If this is not possible, an access path must be provided parallel to the direction in which the mast erection is planned. A separate padded road can be used. It must be ensured that the pads are interconnected and the access path has the necessary ultimate load.

No obstacles must be present in a radius of 50 m around the crane. Material accumulations of any kind within the assembly area must be removed or relocated in consultation with Senvion.

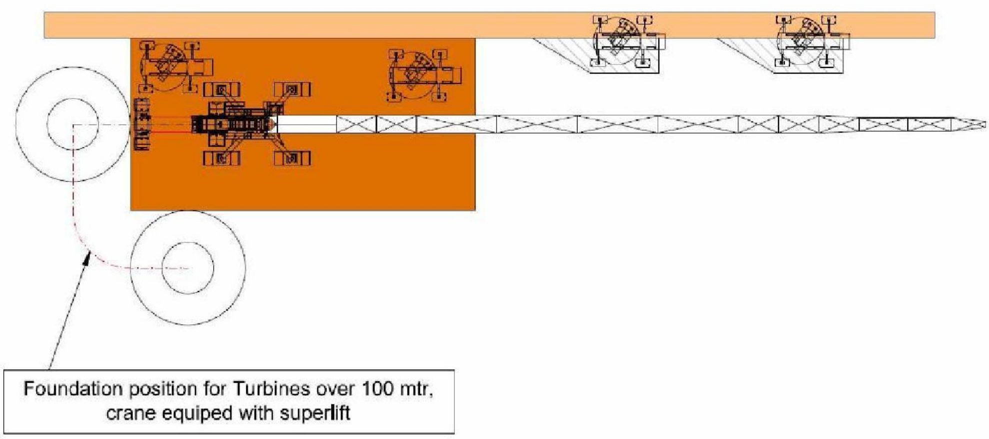


Figure 11: Possible foundation and crane positions for the 3.0M122 (illustrative purpose)

Comment:
Because of the height limit of the selected crane configuration, which is sufficient for the existing hub height, the height difference between the crane pad and the upper edge of the tower foundation section should not be more than 2.00 m. If this cannot be ensured for technical reasons, it is necessary that Senvion project management be contacted, as detailed crane planning is required in this case.

8.2 Requirements on the design and load-bearing capacity of the crane pads

The crane pads must be planned by a competent person on the basis of applicable local statutory regulations:

- D, IT: DIN / European standards for geotechnology
- F: NF standards
- UK/AUS/US/CAN: Consistent with the local standards

8.2.1 Load

The crane pads must be planned so that they can securely bear a maximum surface pressure of 200 kN/m² (220 kN/m² for crawler cranes) below the load distribution (crane steel mats, Bongossi mats). The 200 kN/m² come from the maximum crane cantilever force of from 200 t (resultant chain pressure force in crawler cranes up to 240 t), which is distributed through the load distribution to the surface of the crane pad.

This planning process must demonstrate the total load-bearing capacity of the crane pad and the substrate (soil layer) for the specified crane load and the corresponding load transfer surface. The design lifetime of the crane pad must meet the contractual agreements between the customer and Senvion.

8.2.2 Soil analysis

The planning must be carried out on the basis of suitable and sufficient soil analyses. The planner must confirm that the existing soil analyses are sufficient to carry out sound and secure planning.

All specific hazards which may be caused by inhomogeneities in the substrate (e.g. peat lenses) must be identified during the planning phase. Identified hazards must be included in the project-specific risk assessment. Measures to remove and/or minimize the hazards or their impacts must be laid down within this document. The objective is to ensure even stiffness below the entire crane pad.

The customer must ensure that the design, implementation, and verification are implemented based on the country-specific standards (an example of the requirements of BRE in the UK is the document "Working Platforms for Tracked Plants":

8.2.3 Required geotechnical support documentation

See section 5.4.

Based on the ascertained layer structure, a load bearing analysis with verification of 2-fold bearing capacity must be carried out for the crane pad. The crane technology (loads, load distribution) used must be taken into account.

8.2.4 Quality control in planning and transfer

On request, the customer must submit all calculations and planning documents created by and for the planner to Senvion for inspection and review. Risk assessments should be carried out in accordance with HSE requirements.

On completion of the crane pads, he or she must confirm that the construction work was carried out in accordance with the planning and must provide detailed specifications on the support of the crane pads. The transfer of the crane pad from the customer to Senvion must be carried out with a visible marking of the platform boundaries.

8.2.5 Data for the soil expert

The requirements for soil parameters are named in 5.3.2.

8.2.6 Crane technology

Depending on availability, the following cranes can be used.

Mobile crane with telescopic boom	With or without tiltable boom
Mobile crane with lattice boom	With or without tiltable boom
Crawler crane with lattice boom	With or without tiltable boom
Mobile crane for unloading and pre-assembly	Min. size 120 t category
Special cranes (project-specific special solution)	
Narrow-gauge crawler crane with lattice boom (to be agreed project-specifically as there are special access path requirements: 250 kN/m^2, negotiable width > 5.5 m)	With or without tiltable boom

The crane actually used is determined by the dimensions of the tower height plus rotor hub, the nacelle weight of the wind turbine and the availability of suitable cranes at the time of assembly.

8.3 Rotor assembly

For the rotor assembly, access to an area around the wind turbine must be made available and granted for Senvion personnel. This area must be flat without slopes, free of obstacles (trees, boulders, walls etc) and accessible by Senvion personnel and forklift to remove the blade frames.

The diameter of the rotor pre-assembly area depends on the WEC series, according t the next table:

MM82/92	100m
MM100	105m
3.4M104	107m
3.2/3.4M114	117m
3.0/3.2M122	125m

If this is not possible, the single blade installation will be needed and the assembly costs will be increased.

For the pre-assembly of the rotor, the height difference in the terrain must not be more than ~1 m between the support points. This is measured from the location of the rotor hub frame up to the location of the blade trestles.

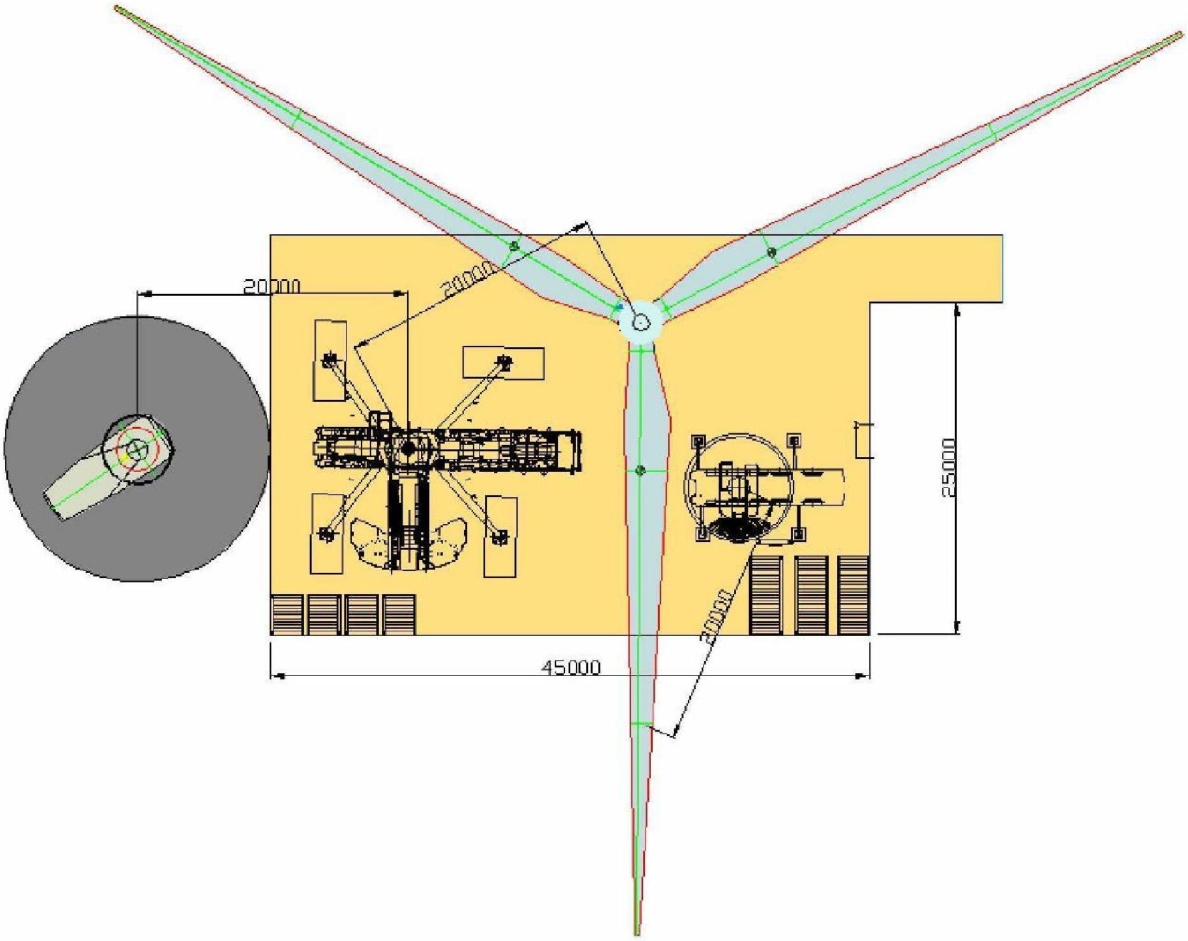


Figure 12: Rotor assembly (illustrative purpose)

8.4 Single blade installation

If single blade installation is used, the requirements for the crane pad do not change. Only the pre-assembly of the rotor and the associated requirements are omitted.

The decision when, how, and where single blade installation is to be used is made by the Senvion project management. The planned assembly method can be derived from the logistics and installation design.

Single blade installation always increases the assembly costs. This must be agreed on a project-specific basis between Senvion and the customer.

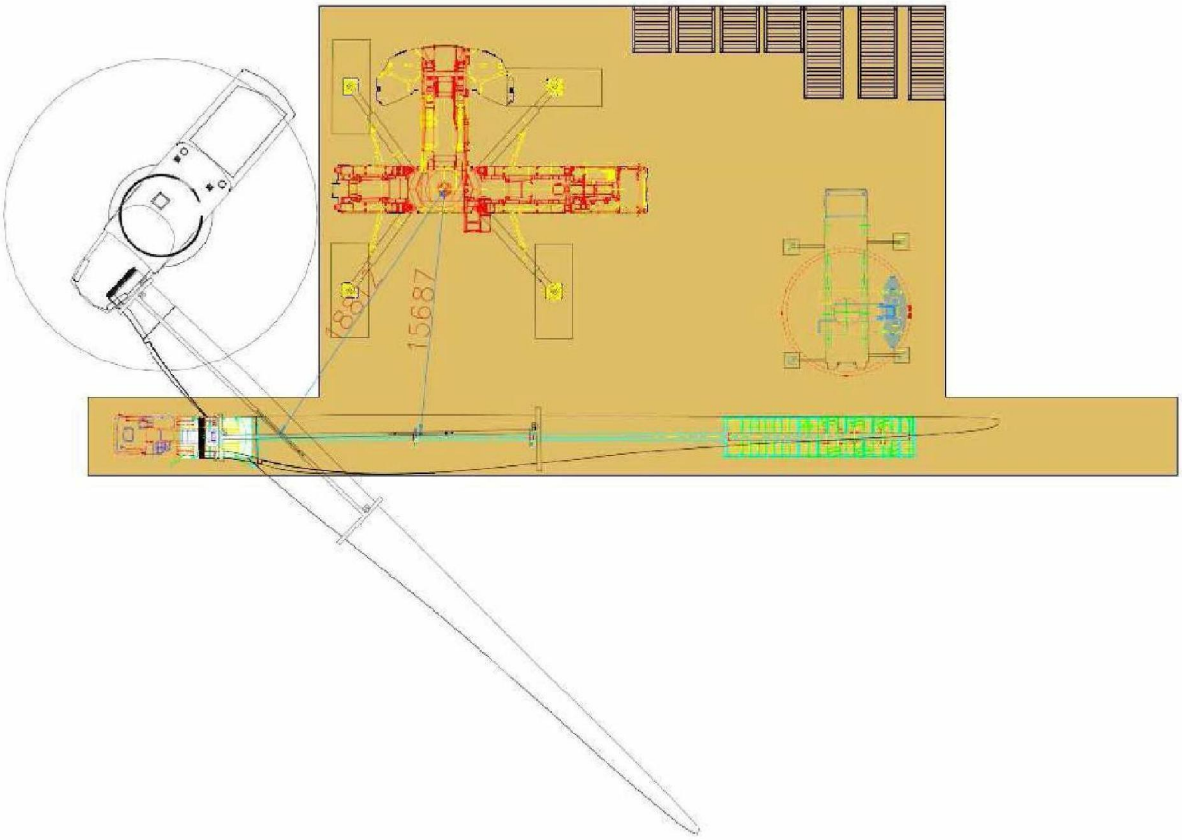


Figure 13: Single blade installation (illustrative purpose)

8.5 Directives for "keyhole construction" (construction in forested areas)

This chapter is provided for advice. It presents a solution for the erection of wind turbines in densely wooded areas and the required associated tree-felling operations. Due to many variables, it must be ensured that each construction site is assessed with suitable expert reports prior to confirming and commencing erection. This document assists customers and project developers in planning erection in wooded areas.

It is necessary to fully remove the trees in order to create the emplacement and the foundation area. The extent of the necessary deforestation around the rotor blades is shown by the green lines and depends on the blade length plus a minimum additional 5 m.

The following two diagrams present examples of possible positions for standard rotor assembly.

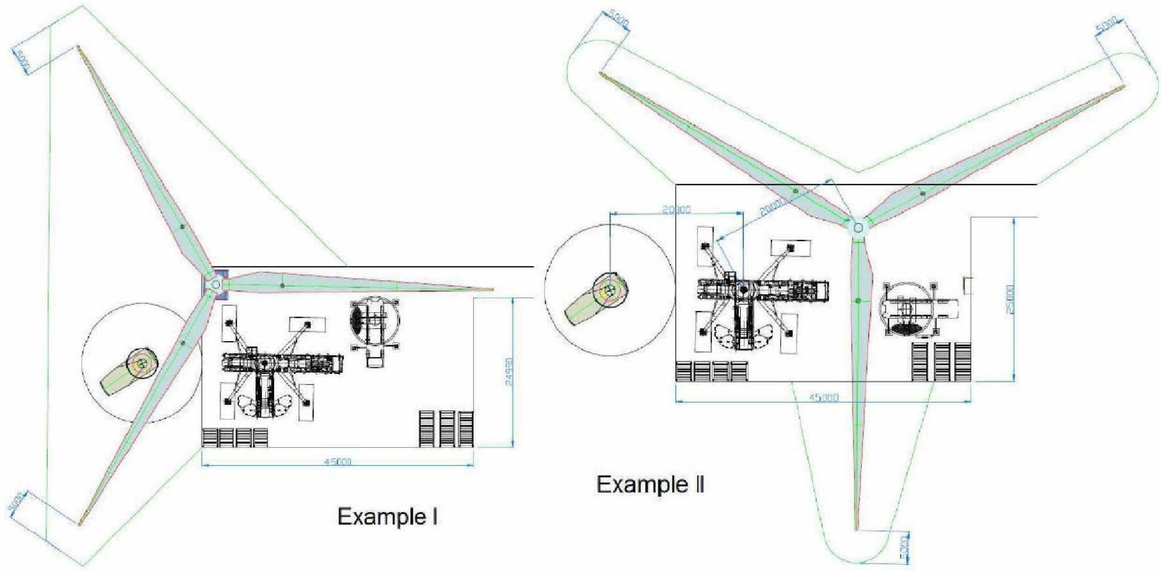


Figure 14: Construction in forestes areas (illustrative purpose)

The green lines show the required free space around the rotor blades. There must also be the option of movement with the safety ropes in order to stabilize the rotor. The length of these ropes depends on the hub height of the WTG plus ~ 25 m.

- Note: Compared with single blade installation, this type of assembly is associated with an increased risk of rotor blade damage.

Due to the fact that this solution falls outside the Senvion specification, a project-specific construction site inspection is required in every case. This is generally carried out by specialists from the construction site management. Following a successful inspection, the customer will promptly be provided with a written declaration containing the prerequisites and general conditions for erection. Senvion reserves the right to reject the suggested solutions if they jeopardize occupational safety. This decision by Senvion must be accepted.

8.6 Access to the wind turbine for assemblers

Clean, safe, and paved access from the crane pad to the wind turbine must be ensured. This access must be constructed with a width of at least 2 m from material of grain size 0/32. This regulation corresponds to the specifications of the HSE department of Senvion.

Travel accidents are the most common cause of longer-term absence from work for employees!

9 Annex IV – Grain distribution curves

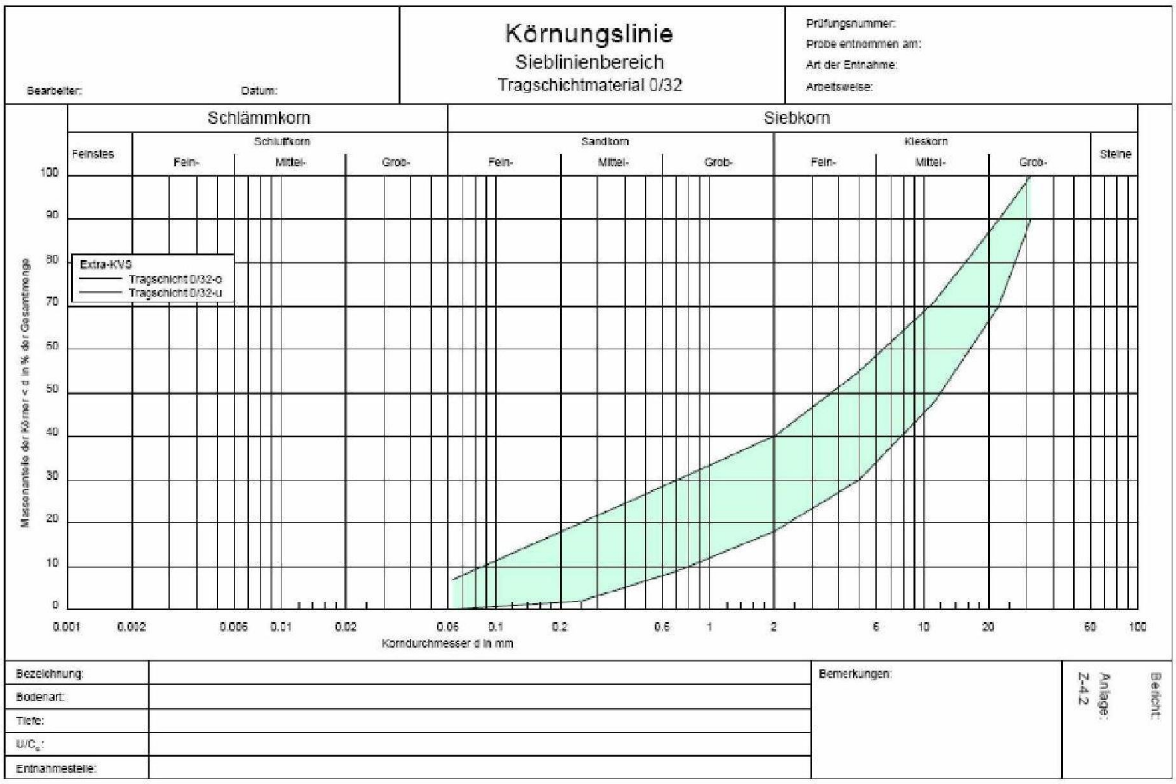


Figure 15: Grain distribution curve for face sheet material 0/32

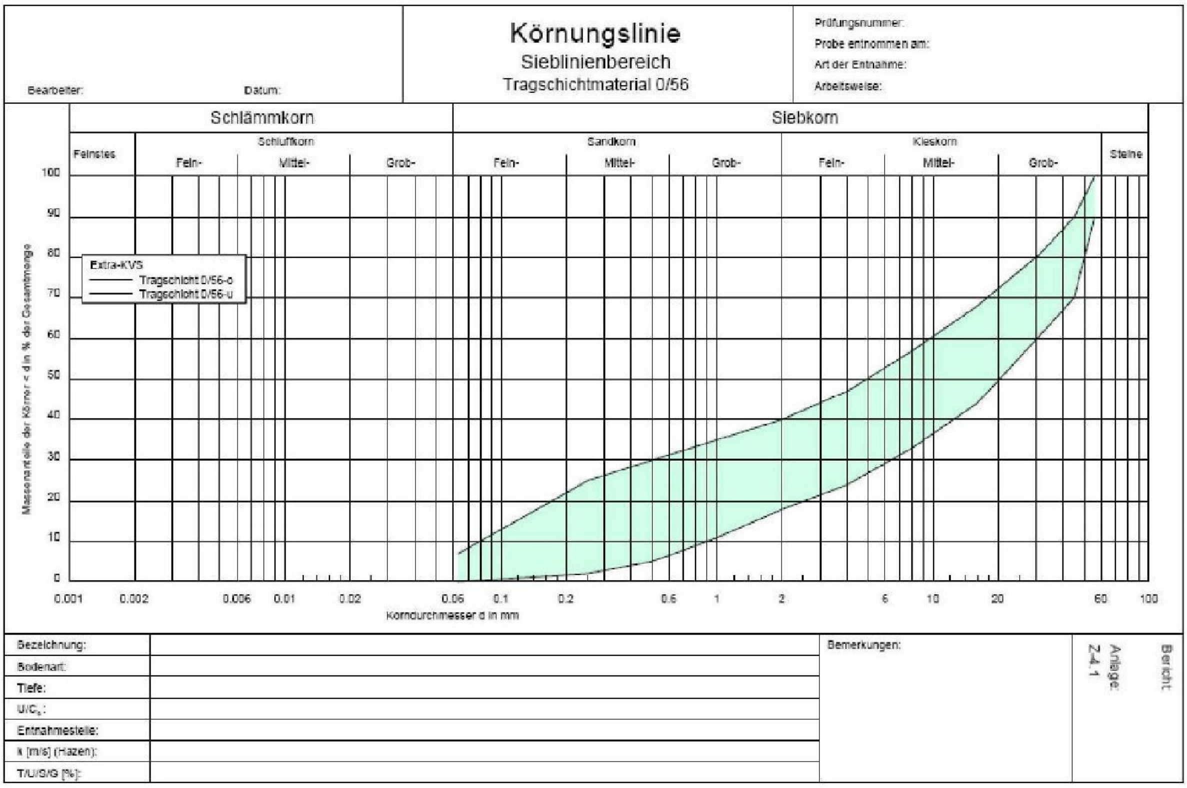


Figure 16: Grain distribution curve for support layer material 0/56