Appendix 3.6 (2 of 2)

Delivery Route Bridge Inspection Report

Keerglen Wind Farm

RECEIVED: 29/08/2024

Sales document

Transport, access roads and crane requirements
Wind turbine class K08 delta

2001709EN

Revision 01 / 2020-04-15

- Translation of the original customer document (E0004929172, rev. 01) -

This is a translation from German. In case of doubt, the German text shall prevail.

Document will be distributed electronically.

Signed original at Nordex Energy GmbH, Engineering Department.

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Turbine generation	Product series	Product
Delta	Delta	N100/3300
		N117/3000 controlled
		N117/3600
		N117/3675
		N131/3000
		N131/3000 controlled
		N131/3300
		N131/3600
		N131/3900

1. Basic information

This document contains basic information for planning road construction and crane hard standing areas, delivery, storage and installations in the course of establishing the infrastructure for wind farms of the K08 delta wind turbine class (N100, N117 and N131 with the specified hub heights). Component dimensions for the design of transport equipment and cranes are also included.

In principle, it must be ensured that during the entire project phase, especially during delivery, storage, installation and for the subsequent service and maintenance work, all trades are accessible at all times throughout the entire construction site, so that all necessary work can be carried out to the full extent. Furthermore, measures on occupational health and safety and environmental protection must be observed at all times and monitored and coordinated by the client.

The planning parameters specified in this document are minimum requirements. Observing these requirements is to ensure a smooth process throughout the entire project phase and permanent compliance with occupational health and safety regulations.

Detailed information on the infrastructure planning is also project-specific and must be agreed upon by all persons involved prior to project start.

Each project location must be analyzed and planned individually taking into account the local and general safety regulations. Project-specific justified and comprehensible changes to and/or deviations from the following specifications can be examined beforehand or in the early planning phase in cooperation with Nordex and implemented after written agreement. In this context, the safety of persons and material is given top priority. If there is no coordination with Nordex project management, the minimum requirements set out below apply.

All data contained in this document describe the current development status of the wind turbine. These data are subject to change due to continuous development. In this case Nordex will provide an updated version of this document.

If the minimum requirements are exceeded, in particular with regard to see chapter 3.2 “Slopes and vertical radii” and see chapter 5 “Crane hard standing area”, additional safety measures or more cost-intensive logistics concepts might be necessary (e.g. internal reloading of main components on the wind farm to reduce the clearing areas in forest locations). The measures are to be agreed upon with Nordex in advance.

NOTE

We expressly point out that all values must be regarded as standard values only.

During the planning and execution of the work to be executed by the client, the valid national technical regulations, statutory provisions and standards must be taken into account in accordance with the current state-of-the-art technology. If the valid national regulations, statutory provisions and standards go beyond the minimum requirements specified below, then these must be observed accordingly.

Further instructions for transport can be requested from Nordex.

The layout of access roads and hard standing areas depends on the transport and erection method.

- The design must be modified for each individual erection site.
- Depending on the site different variants are possible.
- Transport weights may also vary with the erection site.

The exact design of access roads, crane hard standing areas and assembly areas must be agreed with Nordex prior to starting the erection work!

Improper design or execution of access roads and crane hard standing areas may subsequently cause considerably higher logistics and erection costs, for example, due to downtimes or additional personnel and/or equipment.

2. Weights, dimensions and handling instructions

2.1 Nacelle

During nacelle transport the drive train, rotor hub and further exterior assemblies (obstacle lights, wind sensors, lightning arresters, etc.) are not assembled yet. The transport frame for the nacelle consists of 4 individual supports, which must be used for transport. All components must always be transported on anti-slip mats, except for sea transport.

All turbine components must always be placed on compacted ground or on crane mats.

Fig. 1 Nacelle (view from the left) with transport supports

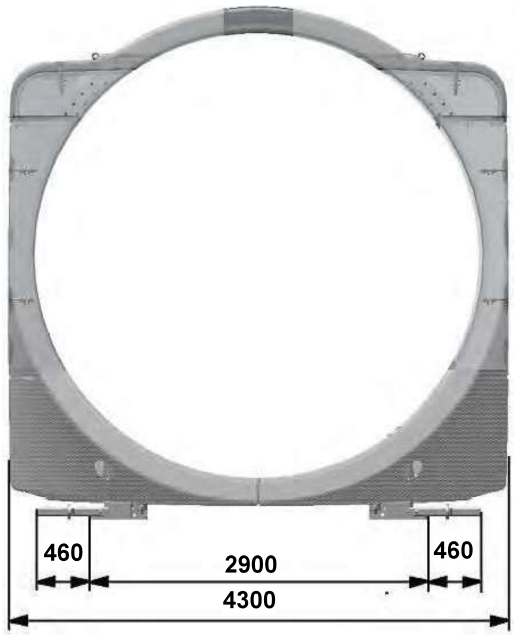


Fig. 2 Nacelle (front view) with transport supports

2.2 Drive train

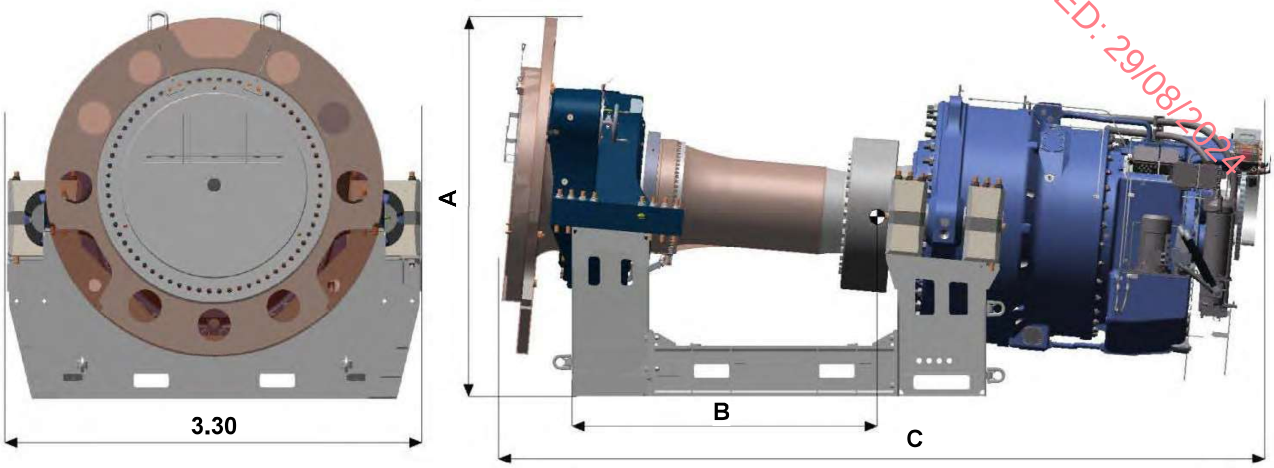


Fig. 3 Dimensions of the drive train on the transport frame (all dimensions in m)

	N100/N117	*N131/3300*	*N131/3600 N131/3900*
A	*2.95*	*3.00*	*3.00*
B	*2.00-2.40*	*2.55-2.81*	*1.9-2.3*
C	*6.10-6.15*	*approx. 6.25*	*approx. 6.25*

Values depend on gearbox specifications and oil filling capacity

The rear section of the gearbox will be protected for transport with a wooden cladding. This cladding is included in the overall length.

2.3 Rotor hub

Rotor hub N100 and N117

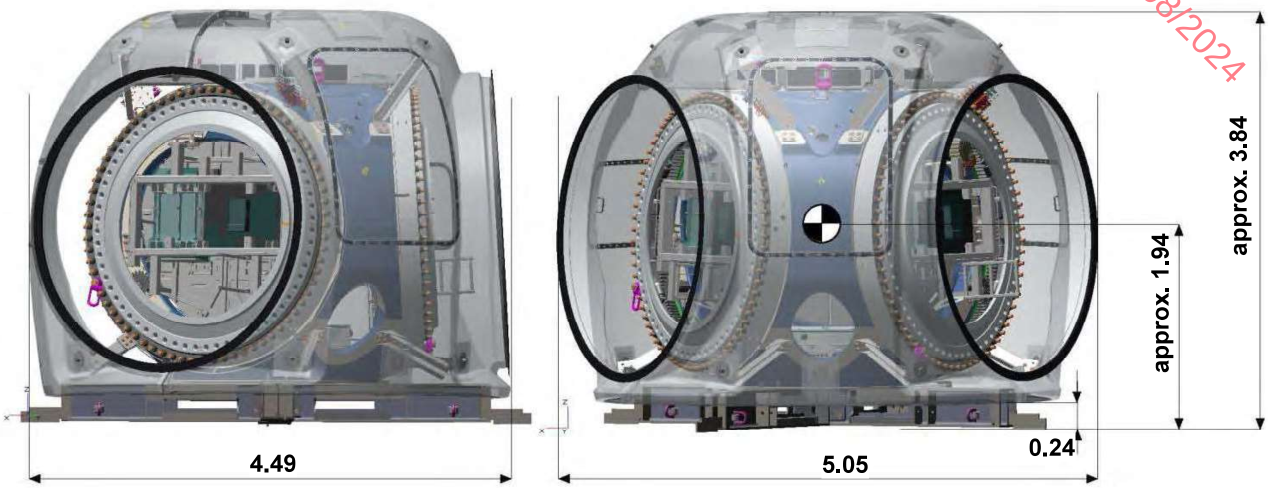


Fig. 4 Rotor hub N100, N117 on the transport frame (dimensions in m)

N131 rotor hub

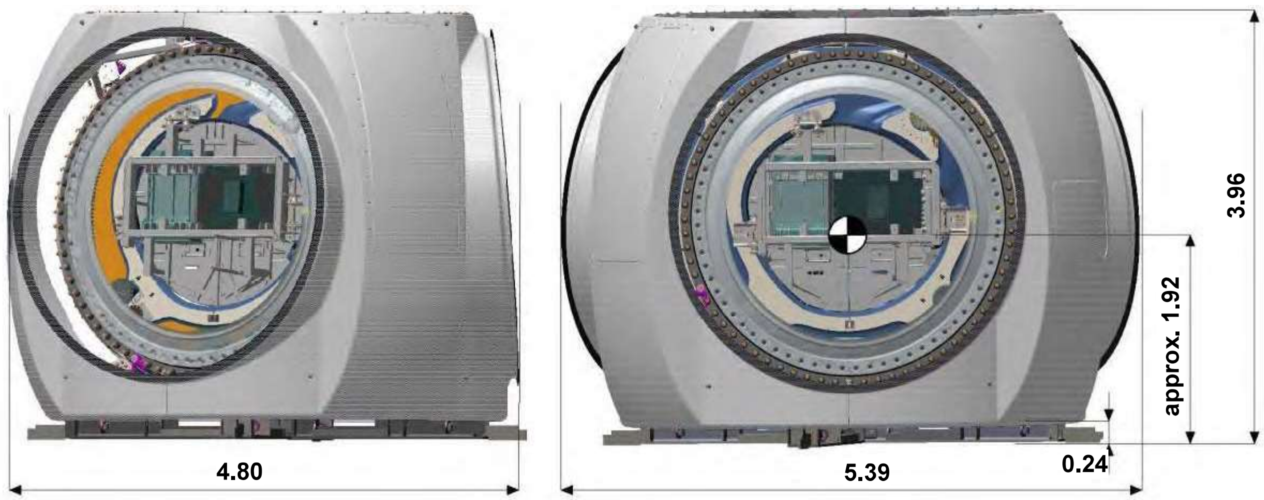


Fig. 5 Rotor hub N131 on the transport frame, ready for transport (dimensions in m)

The rotor hubs are delivered on a divisible transport frame.

Anti-slip mats must be used for transport.

2.4 Rotor blade

Each rotor blade is delivered on two transport frames using a trailer. One of the transport frames is fastened to the blade root, the other one to the support point.

In addition to the center of gravity and support point, the drawing shows the defined points where the webbing slings can be attached. The blade must only be lifted at these points as the wall thickness is reinforced in these areas.

When using a blade lifter for single blade assembly, this will be attached to point C.

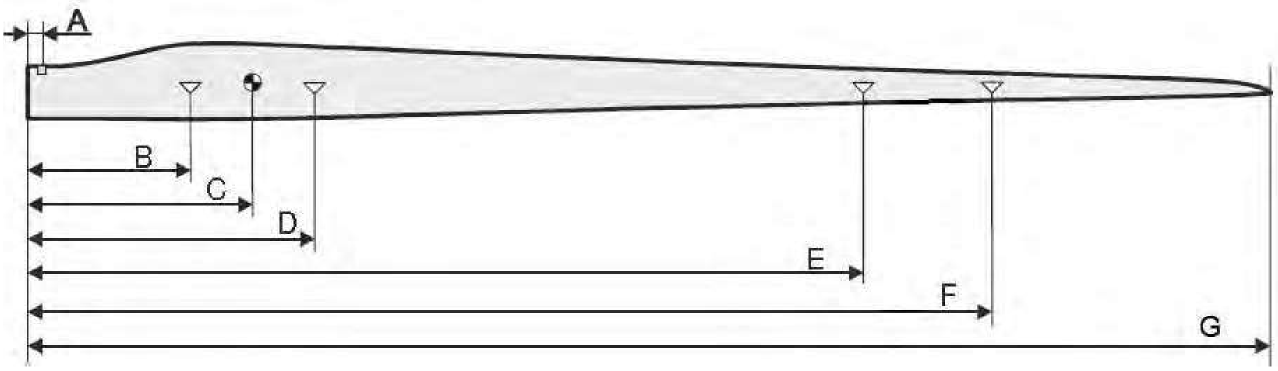


Fig. 6 Blade transport dimensions – side view

Rotor blade		NR50	NR58.5	NR65.5
A	Lifting point root	0.3/1.01	0.32/1.0[1]	0.30/0.9[1]
B	Lifting point for single blade assembly (SBA)	Upon request	Upon request	
C	Center of gravity	14.40	15.90	17.80
D	Lifting point SBA	Upon request	Upon request	
E	Start of handling area	33.55	38.00	42.50
F	End of handling area	36.00	43.00	53.50
G	Length	48.7	57.60	64.70
J	Transport width	3.36		4.20
	Road transport	-	3.36	-
	Sea transport	-	3.22	-
K	Transport height	3.46		3.18/3.32[2]
	Road transport	-	2.51	-
	Sea transport	-	3.30	-

1 Lifting point with/without rain deflector

2 Depends on the use of an additional base frame

Examples, all dimensions in meters [m].

Details are to be agreed upon with Nordex in advance.

Single-blade assembly with the aid of lifters at the center of gravity.

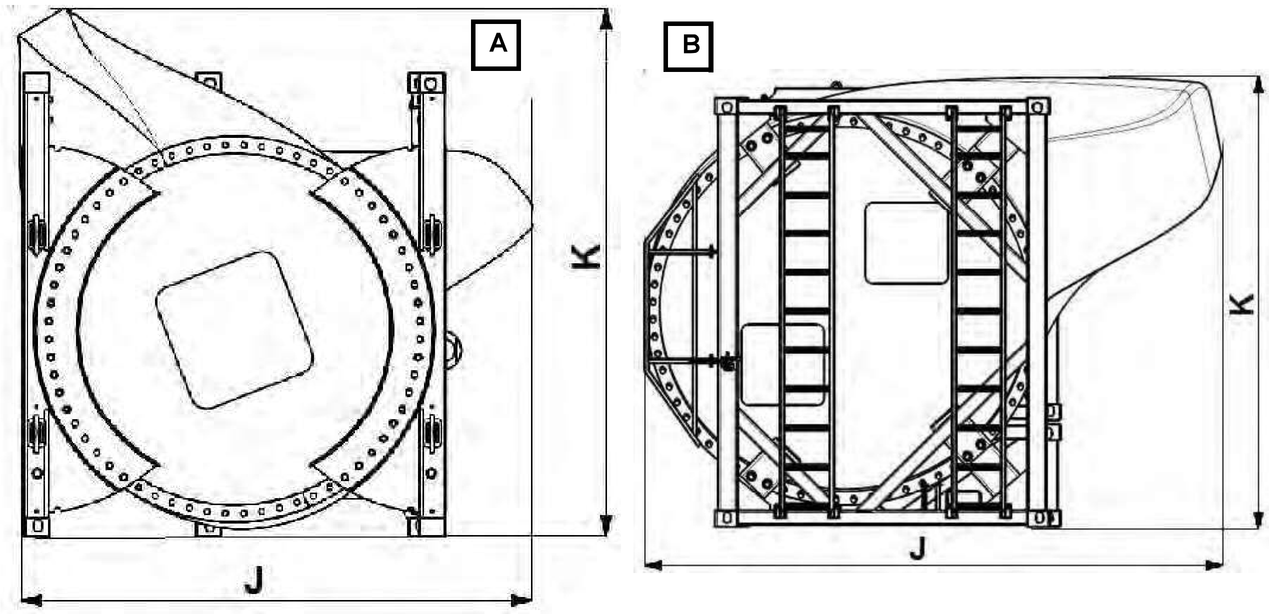


Fig. 7 Blade transport dimensions, view from the blade root; example for sea transport (A) and road transport (B)

2.5 Weights and dimensions of the components

2.5.1 Weights and dimensions with transport frames

Nacelle	N100/3300	N117	N131
Length/ width/ height (without roof structures)	12.81 m/ 4.30 m/ 4.00 m		
Weight of nacelle without drive train*	max. 59.86 t		
Weight of drive train only*	max. 64.37 t		max. 69.85 t

Rotor hub	N100/3300	N117	N131
Dimensions (L x W x H) Overall spinner dimensions	4.49 m x 5.05 m x 3.84 m		4.82 m x 5.39 m x 3.96 m
Weight*	max. 37.56 t		max. 46.98 t

Rotor blade	N100	N117	N131
Length with/without blade bolts	49 m/ 48.7 m	57.6 m/ 57.3 m	64.7 m/ 64.4 m
Weight per blade*	max. 13.14 t	max. 13.14 t	max. 17.6 t

Bottombox switch cabinet	N100, N117 and N131
Dimensions (L x W x H)	2.2 m x 1.2 m x 2 m
Weight	approx. 2.9 t

* The weights depend on the selected variant and weight tolerance of the components

2.5.2 Weights and dimensions during erection (without transport frame)

Nacelle	N100	N117	N131
Length/ width/ height (without roof structures)	12.81 m/ 4.30 m/ 4.00 m		
Weight of nacelle without drive train*	max. 60.53 t		
Weight of drive train only*	max. 62.4 t	max. 62.4 t	max. 67.87 t

Rotor hub	N100	N117/3600	N131
Dimensions (L x W x H) Overall spinner dimensions	4.49 m x 5.05 m x 3.60 m		4.82 m x 5.39 m x 3.72 m
Weight*	max. 36.73 t	max. 36.73 t	max. 44.76 t

Rotor blade	N100	N117	N131
Weight per blade*	max. 11.7 t	max. 11.7 t	max. 15.7 t

Transformer	N100, N117 and N131
With the transformer installed in the tower the transformer substation is omitted Individual components per wind turbine:	
Transformer	approx. 10.0 t 2.7 m x 1.3 m x 2.85 m (L x W x H)
Medium-voltage switchgear	approx. 2.0 t 2.3 m x 1.2 m x 2.3 m (L x W x H)

* The weights depend on the selected variant and weight tolerance of the components

Transformer substation
The transformer substation and wind turbine must not be erected at the same time. For exact dimensions and weights refer to the manufacturer as these are project-specific.

2.6 Transport devices

Transport devices for all wind turbines	Weight
Nacelle	approx. 1.19 t
Drive train	approx. 3.17 t
Rotor hub	N100/N117: approx. 2.14 t N131: approx. 3.64 t
Rotor blade (blade root/tip) depending on transport method	N100/N117: approx. 600 kg / approx. 840 kg N131: approx. 430 kg / 1070 (1450) kg*
Switch cabinet/converter spreader bars	Approx. 100 kg (transport spreader bars remain on switch cabinet)

* without (with) underframe for tip frame

2.6.1 Transport devices for the nacelle N100, N117 and N131

- Front bearing surface: 500 x 400 mm
- Rear bearing surface: 500 x 420 mm
- Load per front support: 18.8 t (incl. acceleration)
- Load per rear support: 29.2 t (incl. acceleration)

The screws for fastening the nacelle are part of the transport supports and must be returned together with the transport supports to Nordex.

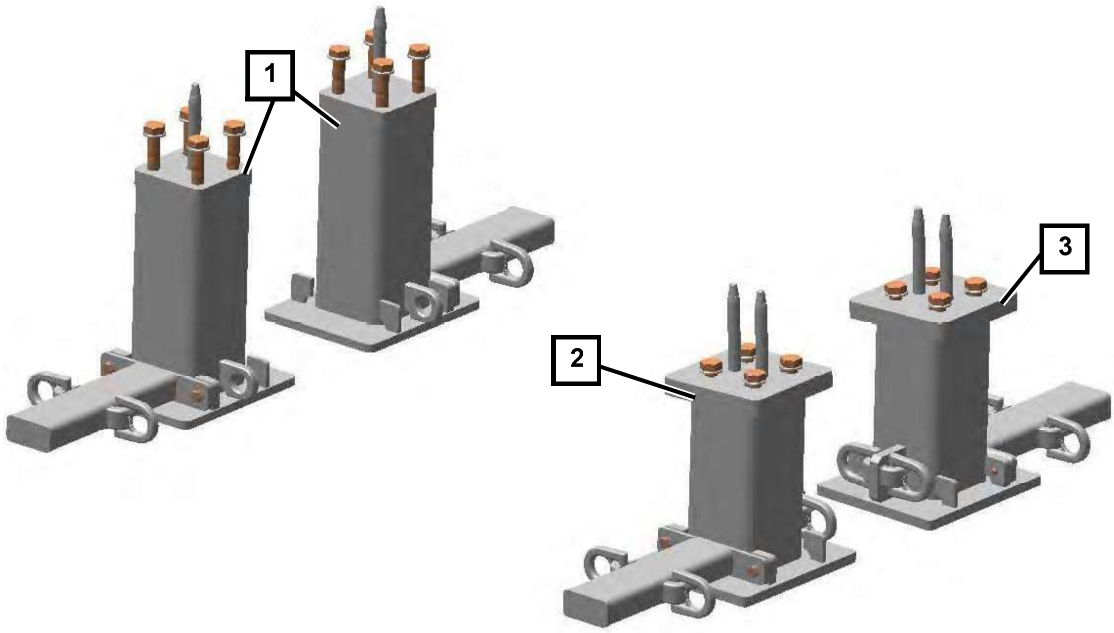


Fig. 8 Nacelle transport supports

1 Front with hollow section
2 Rear left with hollow section
3 Rear right with hollow section

2.6.2 Transport device for the drive train N100, N117 and N131

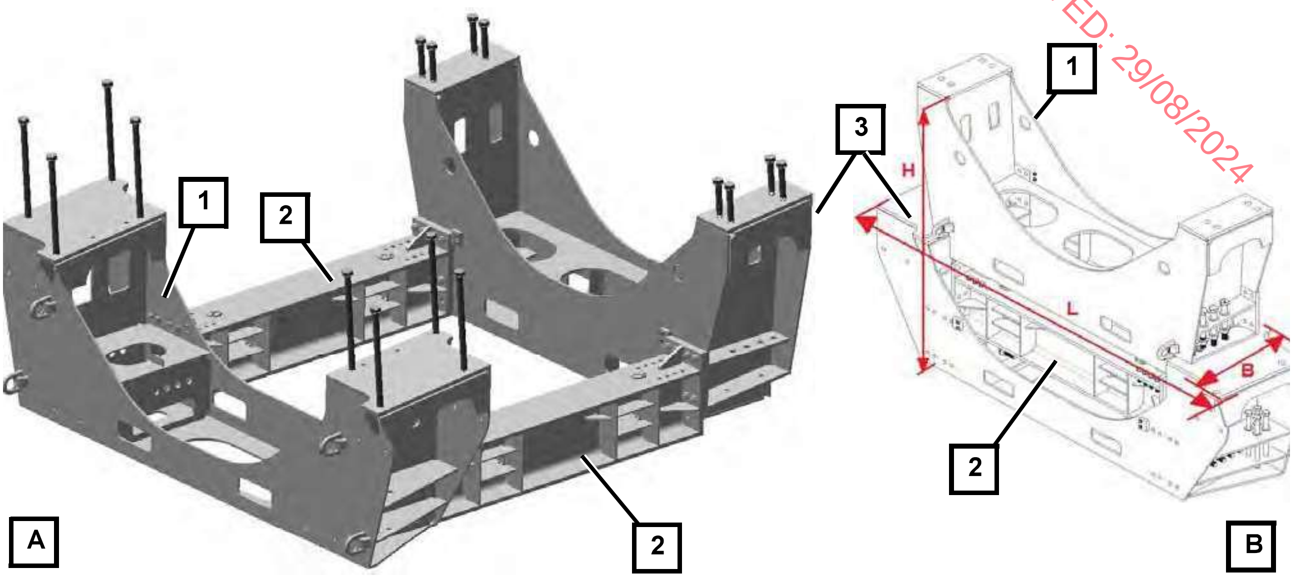


Fig. 9 Transport frame drive train and lanyard (A) and assembled in space-saving way for return transport (B)

1 Rotor bearing support
2 Longitudinal beam
3 Gearbox support

The transport device for the gearbox supports can be disassembled into 3 large sections and must be re-assembled in a space-saving way for return transport, see fig.9B.

All fastening screws are part of the transport device and must be returned to Nordex together with the transport frames.

Note: For N100/N117 wind turbines, it may also be possible to use the old transport devices with the dimensions L: 4.31 m; W: 2.30 m; H: 2.24 m for 3 folded and stacked frames.

2.6.3 Transport device for the rotor hub

The transport devices can be stacked and screwed together for return transport. The round wood plate must also be returned as long it is not damaged.

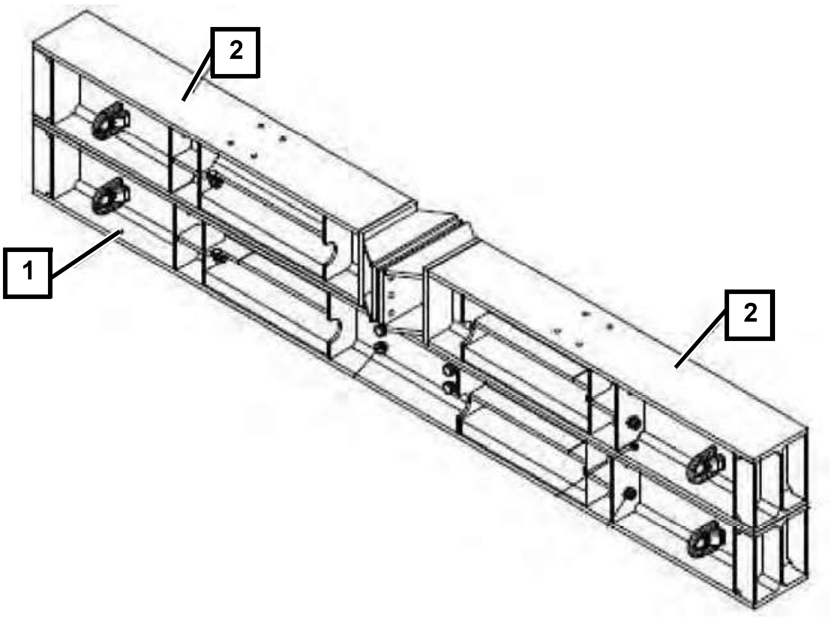


Fig. 10 Rotor hub transport frame assembled for return transport

1 Beam, long
2 Beam, short

Note: For N100/N117 wind turbines, it may also be possible to use the old transport devices with the dimensions H: 0.50 m; W: 2.07 m; L: 3.00 m.

2.7 N100/3300 towers

Hub height		75 m	85 m	100 m
Tower type		Tubular tower MT5	Tubular tower MTR5	Tubular tower MTR5
1st tower section (TOP) Length Ø top Ø bottom Weight	 m m m t	 31.2 3.26 4.02 47.6	 30.0 3.26 4.02 41.8	 29.8 3.26 4.27 50.0
2nd tower section (MID3) Length Ø top Ø bottom Weight	 m m m t			 24.0 4.27 4.27 60.0
3. Tower section (MID2) Length Ø top Ø bottom Weight	 m m m t		 24.0 4.02 4.02 48.7	 18.1 4.27 4.29 63.7
4. Tower section (MID1) Length Ø top Ø bottom Weight	 m m m t	 24.0 4.02 4.03 54.8	 15.1 4.02 4.03 47.2	 12.2 4.29 4.29 60.4
5. Tower section (Bottom) Length Ø top Ø bottom Ø T flange Weight (TIT/TAT)	 m m m m t	 16.7 4.03 4.00 4.30 59.0/59.2	 12.8 4.03 4.02 4.30 54.3	 12.7 4.29 4.00 4.30 74.2/71.9

Due to transport equipment, the transport height may exceed the tower diameter by 7 cm. Each lifting tackle has an overall height of 15 cm and thus extends the tower sections.

Changes in weight of up to 2 % must be considered. The centers of gravity may deviate from the center of the tower sections by up to 5 %.

TAT: Transformer outside tower

TIT: Transformer inside tower

2.8 N117/3600, N117/3675 and N117/3000 Controlled towers

Hub height		76 m	84 m*	91 m	106 m	120 m	141 m
Tower type		Tubular tower TS76	Tubular tower TS84	Tubular tower TS91	Tubular tower TS106	Tubular tower TS120	Hybrid tower TCS141
Tower section TOP Length Ø top Ø bottom Weight	 m m m t	 29.05 3.26 4.01 45.7	 34.02 3.26 4.02 50.2	 35.06 3.26 4.02 52.4	 35.00 3.26 4.23 58.3	 34.21 3.26 4.02 52.8	 30.91 3.26 4.29 46.6
Tower section MID3 Length Ø top Ø bottom Weight	 m m m t	-	-	-	-	 29.94 4.02 4.26 66.4	-
Tower section MID2 Length Ø top Ø bottom Weight	 m m m t	-	-	-	 29.92 4.25 4.26 76.8	 21.04 4.26 4.26 66.4	-
Tower section MID1 Length Ø top Ø bottom Weight	 m m m t	 26.97 4.01 4.02 53.3	 26.95 4.02 4.02 55.8	 29.95 4.02 4.02 63.8	22.54 4.26 4.28 - 79.7	18.12 4.26 4.27 - 67.1	-
Tower section Bottom Length Ø top Ø bottom Ø T flange Weight (TIT/TAT)	 m m m m t	 16.87 4.02 4.03 4.30 54.4	 19.86 4.02 4.04 4.30 68.8/66.8	 22.83 4.02 4.04 4.30 74.8	 15.38 4.28 4.05 4.30 80.8/78.7	 13.53 4.27 4.05 4.30 73.8/71.5	 29.95 4.29 4.29 4.29 62.9

* N117/3675 only

Due to transport equipment, the transport height may exceed the tower diameter by 7 cm. Each lifting tackle has an overall height of 15 cm and thus extends the tower sections.

Changes in weight of up to 2 % must be considered. The centers of gravity may deviate from the center of the tower sections by up to 5 %.

2.9 N131/3300 towers

Hub height		134 m	164 m
Tower type		Hybrid tower PH134	Hybrid tower PH164
1st tower section (TOP) Length Ø top Ø bottom Weight	 m m m t	 28.3 3.26 4.28 40.8	 35.00 3.26 4.29 53.0
2nd tower section (MID3) Length Ø top Ø bottom Weight	 m m m t		
3. Tower section (MID2) Length Ø top Ø bottom Weight	 m m m t		
4. Tower section (MID1) Length Ø top Ø bottom Weight	 m m m t	 23.0 4.28 4.29 41.8	 26.36 4.29 4.29 54.4
5. Tower section (Bottom) Length Ø top Ø bottom Ø T flange Weight	 m m m m t		

Due to transport equipment, the transport height may exceed the tower diameter by 7 cm. Each lifting tackle has an overall height of 15 cm and thus extends the tower sections.

Changes in weight of up to 2 % must be considered. The centers of gravity may deviate from the center of the tower sections by up to 5 %.

2.10 N131/3600, N131/3000 Controlled and N131/3900 towers

Hub height		84 m	99 m*	106 m*	114 m	120 m	134 m	134 m
Tower type		Tubular tower TS84	Tubular tower TS99	Tubular tower TS106	Tubular tower TS114	Tubular tower TS120	Tubular tower TS134	Hybrid tower TCS134
Top section (TOP)								
Length	m	34.02	30.00	35.00	31.53	34.21	32.93	30.91
Ø top	m	3.26	3.26	3.26	3.26	3.26	3.26	3.26
Ø bottom	m	4.02	4.02	4.23	4.02	4.02	4.02	4.29
Weight	t	50.2	43.0	58.3	47.3	52.8	50.2	45.6
MID4 section								
Length	m	-	-	-	-	-	29.41	-
Ø top	m						4.02	
Ø bottom	m						4.26	
Weight	t						62.5	
MID3 section								
Length	m	-	-	-	26.96	29.94	24.01	-
Ø top	m				4.02	4.02	4.26	
Ø bottom	m				4.02	4.26	4.27	
Weight	t				54.8	66.4	68.7	
MID2 section								
Length	m	-	25.00	29.92	23.07	21.04	18.15	-
Ø top	m		4.02	4.25	4.02	4.26	4.27	
Ø bottom	m		4.26	4.26	4.26	4.26	4.27	
Weight	t		49.7	76.8	65.0	66.4	67	
MID1 section								
Length	m	26.95	25.00	22.54	17.34	18.12	14.72	23.00
Ø top	m	4.02	4.26	4.26	4.26	4.26	4.27	4.29
Ø bottom	m	4.02	4.26	4.28	4.27	4.27	4.06	4.29
Ø (bottom) T flange	m	-	-	-	-	-	4.30	-
Weight	t	55.8	65.4	79.7	60.4	67.1	71.5	43.9
Bottom section								
Length	m	19.86	15.84	15.38	11.95	13.53	11.63	-
Ø (top) T flange	m	-	-	-	-	-	4.30	
Ø top	m	4.02	4.26	4.28	4.27	4.27	4.06	
Ø bottom	m	4.04	4.04	4.05	4.05	4.05	4.07	
Ø T flange	m	4.30	4.30	4.30	4.30	4.30	4.30	
Weight (TIT/TAT)	t	68.8/66.8	68.3/65.4	80.8/78.7	60.3/59.1	73.8/71.5	74,1/72.8	

* not for N131/3900

Due to transport equipment, the transport height may exceed the tower diameter by 7 cm. Each lifting tackle has an overall height of 15 cm and thus extends the tower sections. Changes in weight of up to 3 % must be considered. The centers of gravity may deviate from the center of the tower sections by up to 5 %.

2.11 Anchor cages

Nordex delivers modular anchor cages which vary in dimensions and weight depending on the turbine type. The anchor cages are delivered as an assembly set and are assembled on site and according to Nordex specifications by the responsible construction company.

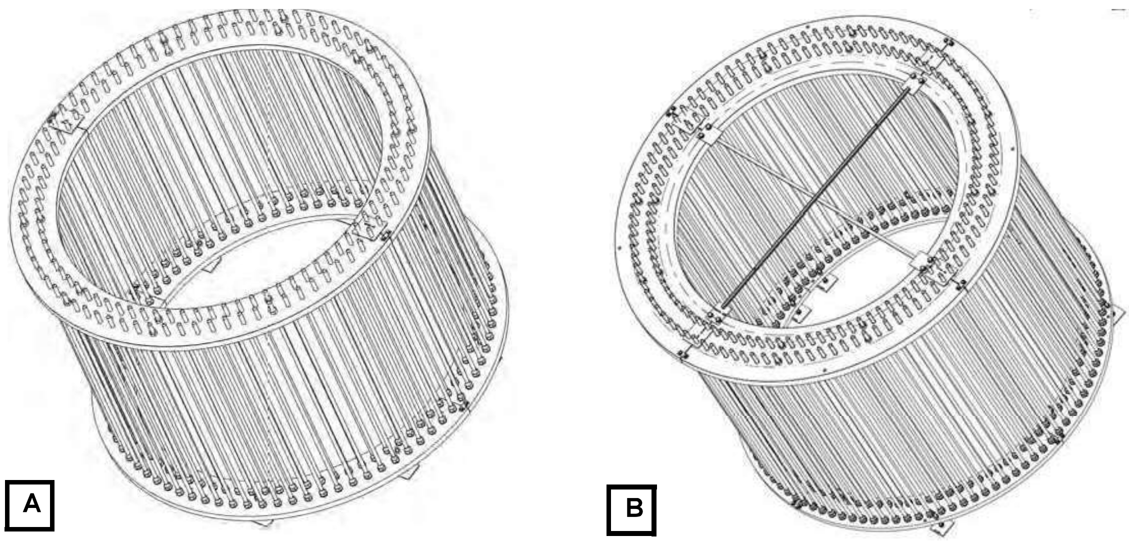


Fig. 11 Example of an anchor cage with 2 x 80 (A), 4 x 50 (B)

Table 1: Example of an anchor cage for N100 R75 and N117 TS91 and N131 TS84 (similar to see fig.11A)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N100 R75 N117 TS91 N131 TS84	Load-spreading plate	2	77 mm	outside Ø 4500 mm	approx. 3.0 t
	Anchor plate	2	70 mm	outside Ø 4460 mm	approx. 1.6 t
	Anchor bolts	160	M42	L=3071 mm	approx. 4.6 t
	Washers, nuts, small parts				approx. 0.4 t

This anchor cage, including transport equipment, weighs approx. 9.6 t.

Table 2: Anchor cage for N100 R85 (similar to see fig.11A)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N100 R85	Load-spreading plate	2	94 mm	outside Ø 4572 mm	approx. 5.2 t
	Anchor plate	2	50 mm	outside Ø 4350 mm	approx. 1.7 t
	Anchor bolts	160	M42	L=3025 mm	approx. 4.7 t
	Washers, nuts, small parts				approx. 0.5 t

This anchor cage, including transport equipment, weighs approx. 12.1 t.

Table 3: Anchor cage for N100 R100 (similar to see fig.11B)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N100 R100	Load-spreading plate	4	160 mm	outside Ø 4720 mm	approx. 11 t
	Anchor plate	4	100 mm	outside Ø 4550 mm	approx. 5.2 t
	Anchor bolts	200	M42	L=3190 mm	approx. 6.2 t
	Washers, nuts, small parts				approx. 0.5 t

This anchor cage, including transport equipment, weighs approx. 22.9 t and is divided into four parts

Table 4: Anchor cage for N117 TS76 (similar to see fig.11B)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N117 TS76	Load-spreading plate	4	60 mm	outside Ø 4450 mm	approx. 2.5 t
	Anchor plate	4	40 mm	outside Ø 4400 mm	approx. 1.5 t
	Anchor bolts	160	M42	L=2850 mm	approx. 4.6 t
	Washers, nuts, small parts				approx. 0.5 t

This anchor cage weighs approx. 9.2 t and is divided into four parts

Table 5: Anchor cage for N117 or N131 TS120 (divided into four parts, similar to see fig.11B) (DIBt version)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N117 TS120 N131 TS120	Load-spreading plate	4	100 mm	outside Ø 4690 mm	approx. 6.6 t
	Anchor plate	4	60 mm	outside Ø 4490 mm	approx. 2.7t
	Anchor bolts	200	M42	L=3560 mm	approx. 7.2 t
	Washers, nuts, small parts				approx. 0.5 t

The complete anchor cage assembly set, including transport equipment, weighs approx. 17.0 t.

Table 6: Anchor cage for N117 TS120, N131 TS120 or N131/TS114 (divided into four parts, similar to see fig.11B) (IEC version)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N117 TS120 N131 TS120 N131 TS114	Load-spreading plate	4	100 mm	outside Ø 4620 mm	approx. 5.9 t
	Anchor plate	4	60 mm	outside Ø 4410 mm	approx. 2.3t
	Anchor bolts	200	M42	L=3560 mm	approx. 7.2 t
	Washers, nuts, small parts				approx. 0.5 t

The complete anchor cage assembly set, including transport equipment, weighs approx. 15.9 t.

Table 7: Anchor cage for N117 or N131 TS106 and N131 TS99 (divided into four parts, similar to see fig.11B)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N117 TS106 N131 TS106 N131 TS99	Load-spreading plate	4	100 mm	outside Ø 4690 mm	approx. 6.6 t
	Anchor plate	4	60 mm	outside Ø 4490 mm	approx. 2.7t
	Anchor bolts	200	M42	L=3325 mm	approx. 6.7 t
	Washers, nuts, small parts				approx. 0.5 t

The complete anchor cage assembly set, including transport equipment, weighs approx. 16.5 t.

Table 8: Anchor cage for N131 TS112 (divided into four parts, similar to see fig.11B)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N131 TS112	Load-spreading plate	4	55 mm	outside Ø 4605 mm	approx. 3.1 t
	Anchor plate	4	50 mm	outside Ø 4410 mm	approx. 1.9 t
	Anchor bolts	200	M42	L=3325 mm	approx. 6.7 t
	Washers, nuts, small parts				approx. 0.5 t

The complete anchor cage assembly set, including transport equipment, weighs approx. 12.2 t.

Table 9: Anchor cage for N131 TS134 (divided into four parts, similar to see fig.11B) (IEC version)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N131 TS134	Load-spreading plate	4	100 mm	outside Ø 4620 mm	approx. 5.9 t
	Anchor plate	4	60 mm	outside Ø 4410 mm	approx. 2.3 t
	Anchor bolts	200	M42	L=3560 mm	approx. 7.2 t
	Washers, nuts, small parts				approx. 0.5 t

The complete anchor cage assembly set, including transport equipment, weighs approx. 15.9 t.

Table 10: Anchor cage for N131 TS134 (divided into four parts, similar to see fig.11B) (DIBt version)

WT	Designation	Parts	Thickness	Dimensions Maximum	Weight Maximum
N131 TS134	Load-spreading plate	4	110 mm	outside Ø 4710 mm	approx. 7.4 t
	Anchor plate	4	60 mm	outside Ø 4490 mm	approx. 2.7 t
	Anchor bolts	200	M42	L=3560 mm	approx. 7.2 t
	Washers, nuts, small parts				approx. 0.5 t

The complete anchor cage assembly set, including transport equipment, weighs approx. 18.0 t.

3. Requirements for the access roads

Planning the wind farm infrastructure on the basis of the minimum requirements stipulated in this document is generally the responsibility of the customer/client. In order to prevent subsequent problems during transport and erection, the planning must be agreed to with Nordex prior to starting the construction work. The infrastructure planning must contain at least the following information:

- Analyses of load-carrying capacity and bearing capacity must be submitted to Nordex before starting construction, see chapter 3.3.6 “Quality inspections, access roads and crane hard standing areas”
- WT sites
- Route planning incl. elevation profile and longitudinal profile with slopes and vertical radii, cross profile, curve radii and obstacles in the clearance area
- Turning areas and turnouts
- Crane hard standing areas regarding foundation and WT site
- Location of the site office/site facilities with possible temporary storage area for main components
- Emergency and assembly routes, which must be accessible for cars, ambulance and rescue vehicles, vans and construction site vehicles
- In the event of restricted visibility, darkness or fog, as well as in adverse weather conditions, no driving operations may be carried out
- Depending on the season and weather the accessibility of the roads must be ensured. For example, the roads must be clear of snow and ice in the winter during the entire construction period and irrigated in the summer to prevent dust developing. These specifications must also be adhered to during a service or maintenance deployment.

To avoid problems during the erection of the wind turbine, the following minimum requirements for the access roads must be met under normal soil conditions.

NOTE

The transport routes must be designed for the entire project period, from the construction phase to the dismantling phase. A distinction is made between “permanent” roads and “temporary” roads. Extensively constructed curve areas for the erection can be dismantled for maintenance operation so that at least accessibility for service vehicles, ambulance vehicles and rescue vehicles or fire-fighting vehicles is ensured.
It must also be taken into account that the heavy-duty vehicles used are not intended for off-road use and are designed for driving on paved roads. Thus, it is not only necessary to ensure the load-carrying capacity of the internal access roads, but also their usability under all weather conditions.

3.1 Loads

The access road for each WT must be capable of supporting the following loads:

Vehicles per wind turbine

- Up to 200 vehicles for tubular steel towers (TS), of which 80 - 120 concrete transport trucks and construction vehicles
- Up to 270 vehicles for tubular steel towers (TS), of which 80 - 120 concrete transport trucks and construction vehicles
- Approx. 15 to 55 heavy trucks for crane erection (depending on the hub height)
- Approx. 8 to 11 heavy trucks with the turbine components (2 to 6 for tower sections, three for rotor blades, three for nacelle, rotor hub and drive train, and several standard trucks for items such as switch cabinet, small parts and erection containers)
- Maximum truck length of 73.5 m for rotor blade transport and 49 m for tower transport
- Required clearance width on public roads, from the construction site access 5 m (for tubular steel towers), 6 m (for hybrid towers)
- Various construction vehicles

Weight of vehicles

- Max. load per axle approx. 12 t (for roads that are used only for transporting components)
- Max. load per axle approx. 16 t (for roads that are used for relocating cranes between two WT sites)
- Max. overall weight: approx. 180 t

3.2 Slopes and vertical radii

3.2.1 Slopes

In compliance with the surface described in Chapter 3.3 “Curves, opportunities for turning, and funnel lanes”, slopes of approx. 10 % (with unbound wearing course) or 12 % (bonded wearing course/asphalt) should not be exceeded under ideal road and weather conditions. In case of steeper slopes, Nordex must always be consulted.

At extra costs, additional tractor units and pushing vehicles as well as tractor units with a suitable hitch (register coupling) must be used so that steeper slopes can also be overcome under the provision of suitable surface conditions/bonded construction. As the length of the entire tractor unit becomes larger this must be considered in road construction planning, especially in terms of curve radii. Additional load securement, where applicable, for slopes in excess of 10 % must be coordinated with Nordex in advance.

Uphill slopes of up to 10 % can only be handled when driving forward. In case that the transport vehicles can handle some of the uphill slopes only by driving backwards (due to local conditions) the maximum grade must not exceed 1.5 % without additional tractor units. The road foundation must also be considered for the respective sections (see the following chapters), as in this case the traction is completely transferred to the front axle of the tractor unit. An adapted design and/or the use of other materials for road construction may be required for the relevant sections.

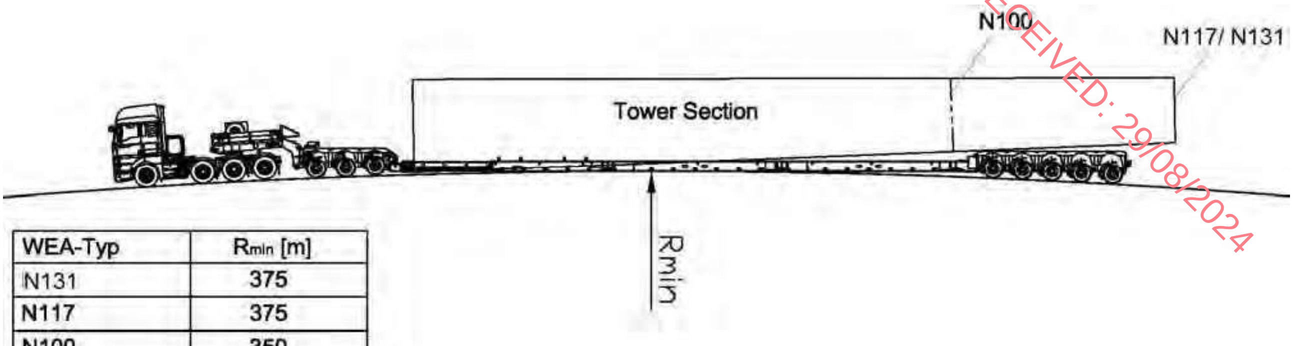
The lateral downhill slope must not be greater than 2 %. This must not be exceeded especially in areas with curves.

Depending on season and weather the requirements for slopes may vary so that additional tractor units or vehicles for deceleration must be used.

3.2.2 Vertical radii

The radii (vertical) for crests and valleys must be at least R375 m for N117 and N131 and R350 m for N100. Over a length of 30.0 m (longest relevant wheelbase) the height difference between two points must not exceed 0.30 m.

If the required minimum radii can be achieved only hardly or not at all due to associated construction measures, on-site inspection must be performed to discuss possible alternatives regarding routes or transport methods.



WEA-Typ	Rmin [m]
N131	375
N117	375
N100	350

Fig. 12 Vertical radius – crest

3.2.3 Clearance profile on a straight route

For all hub heights (see fig.17)		
H	Clearance height	Approx. 4.50 m to 6.00 m (depending on transport method)
W	Clearance width	5.00 m (concrete hybrid tower: 6.00 m)

The clearance height on public roads generally is approx. 4.5 m due to bridges. On the access roads to the construction site a clearance height of 5 m to 6 m and a clearance width of at least 5 m must be ensured, depending on the project and location. For concrete hybrid towers a clearance width of at least 6 m must be ensured to enable the transport of pre-fabricated concrete elements.

If it is not possible to adopt the method of transport employed for the route to the construction site access for the internal access roads due to local conditions (topography, roadway arrangement, obstacles) components may be trans-shipped to other means of transport, if required, which enable the delivery to the crane hard standing area. The crane capacities needed for such purposes and the transshipping areas near or on the construction site must be agreed to with Nordex in advance. A corresponding transport, reloading, and storage concept must be prepared, taking into account the local conditions and the feasibility of measures to be taken. In this case, the minimum requirement for the clearance profile (height) is 6 m.

Any obstacles along the route inside the wind farm must be clearly marked for traffic. Especially when crossing gas and/or water pipes, this must be appropriately examined before the beginning of the transport. The results must be submitted to Nordex for inspection. The client is fully responsible for the marking.

Any obstacles in the clearance area (e.g. when crossing under power lines) must be clearly marked by a guard structure made of non-conductive material on both sides of the power line, at adequate safety distance (see “Table 11: Mandatory safety distances to power lines”). Posts and crossbars must be marked with signal colors to prevent damage from construction site traffic of any kind. In addition, warning signs that indicate electrical hazards and the ground clearance must be put up at the entrances. During darkness and restricted visibility, the signs must be illuminated accordingly.

NOTE

Independent of the above mentioned safety instructions, at least the national safety regulations of the grid operator must be observed.

Table 11: Mandatory safety distances to power lines

Voltage	Safety distance (in accordance with DIN VDE 0105 or comparable country-specific standard)
Up to 1 kV	1 m
up to 110 kV	3 m
up to 220 kV	4 m
up to 380 kV	5 m

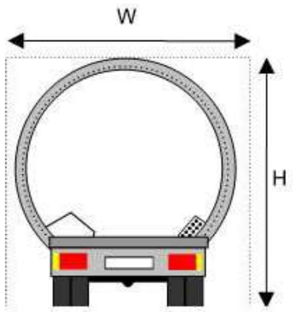


Fig. 13 Clearance profile

3.3 Curves, opportunities for turning, and funnel lanes

3.3.1 Curves

Examples for the space required by turbine components in different curves. The examples apply to left and right curves.

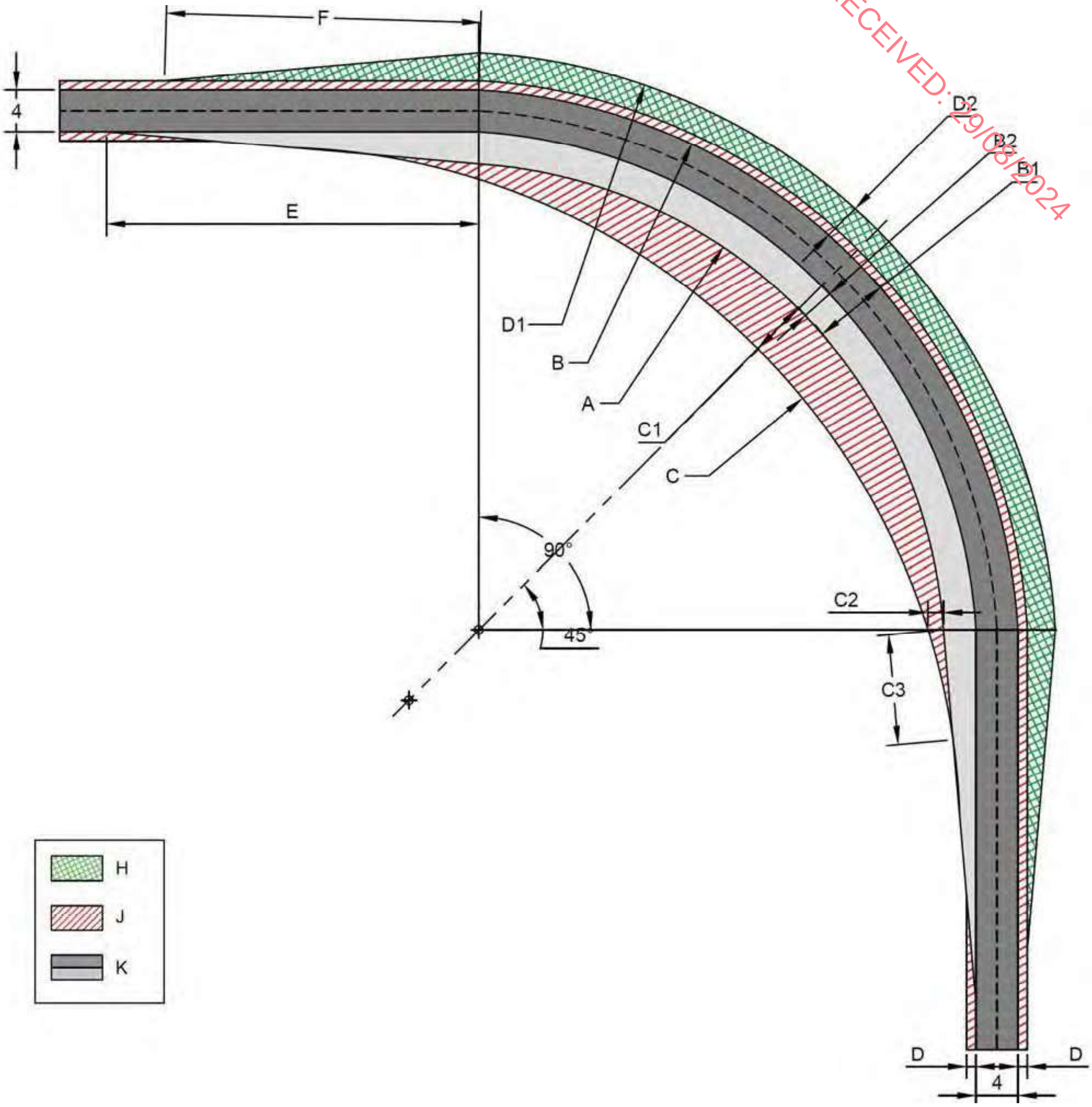


Fig. 14 *Minimum required structural support for 90° curves, general, without using an additional towing vehicle*

H – Outer slewing area / rotor blade projection 1.50 m above ground level (GL)

J – Inner slewing area + clearance profile / tower section projection 0.20 m above ground level (GL)

K – Roadway / roadway extension = GL

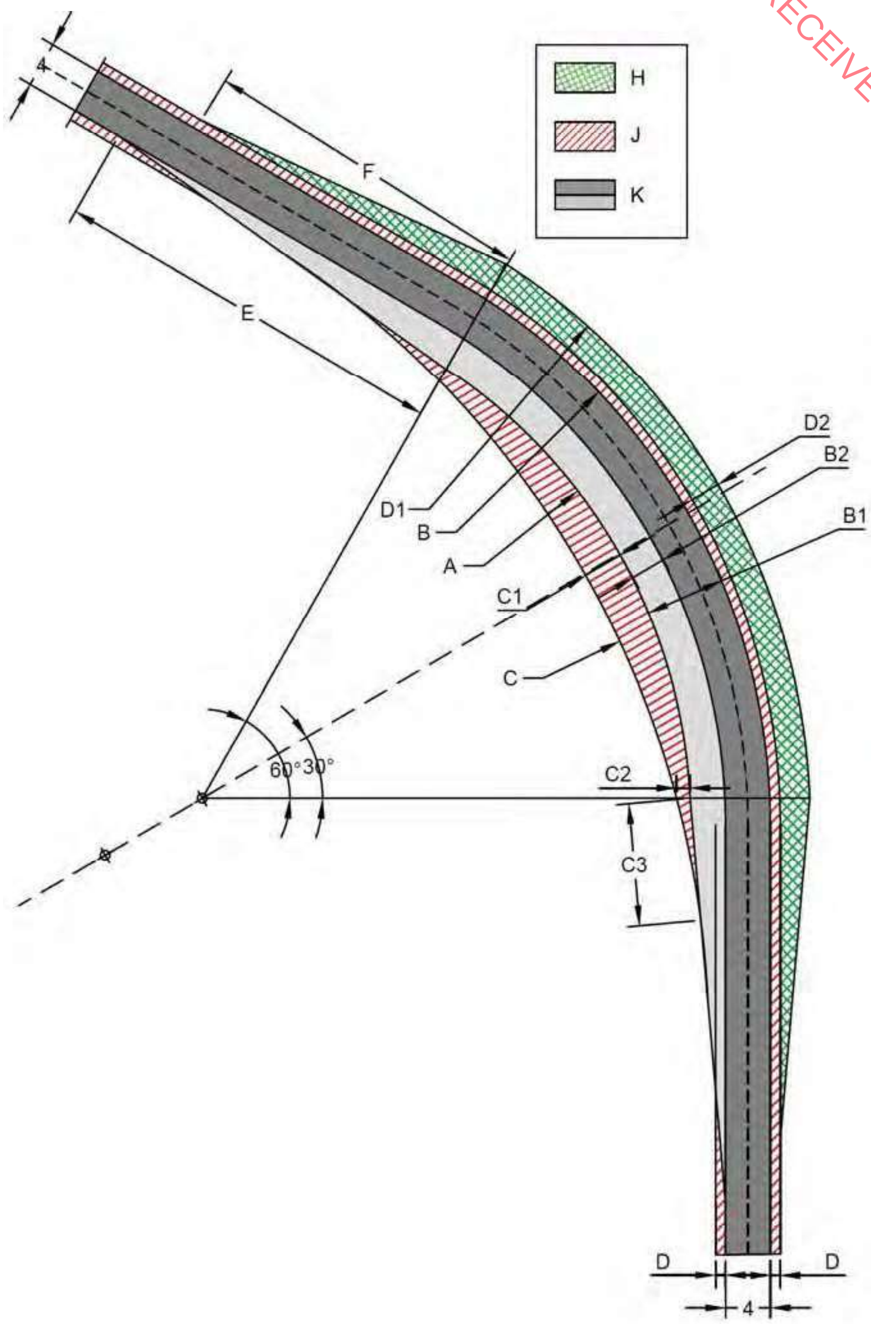


Fig. 15 *Minimum required structural support for 120° curves, general, without using an additional towing vehicle*

H – Outer slewing area / rotor blade projection 1.50 m above ground level (GL)

J – Inner slewing area + clearance profile / tower section projection 0.20 m above ground level (GL)

K – Roadway / roadway extension = GL

Table 12: Traversing and slewing areas for N100

	N100/90°	N100/120°	r 50 m ≤ r min ≤ r 150m m			
A	r 35 m	r 35.5 m	r 75 m	r 100 m	r 125 m	r 150 m
B	r 42.5 m	r 42.5 m	r 82 m	r 106 m	r 130.5 m	r 155 m
B1	7.50 m	7 m	7 m	6 m	5.5 m	5 m
B2	3.50 m	3 m	3 m	2 m	1.5 m	1 m
C	r 50 m	r 50 m	-	-	-	-
C1	5.40 m	3.60 m	4.5 m	3 m	2 m	1 m
C2	1.50 m	2 m	-	-	-	
C3	35 m	35 m	30 m	20 m	10 m	-
D	1 m	1 m	1 m	1 m	1 m	1 m
D1	r 47.5 m	r 47.5 m	-	-	-	-
D2	5 m	5 m	5 m	4 m	3.5 m	3 m
E	35 m	35 m	30 m	20 m	15 m	10 m
F	35 m	35 m	30 m	25 m	20 m	15 m
G*	55 m	-	-	-	-	-

Table 13: Traversing and slewing areas for N117

	N117/90°	N117/120°	r 50 m ≤ r min ≤ r 150m m			
A	r 50 m	r 50.5 m	r 75 m	r 100 m	r 125 m	r 150 m
B	r 57.5 m	r 57.5 m	r 82 m	r 106 m	r 130.5 m	r 155 m
B1	7.50 m	7 m	7 m	6 m	5.5 m	5 m
B2	3.50 m	3 m	3 m	2 m	1.5 m	1 m
C	r 58 m	r 58 m	-	-	-	-
C1	2.60 m	3.30 m	4.5 m	3 m	2 m	1 m
C2	2 m	2 m	-	-	-	
C3	25 m	25 m	20 m	15 m	10 m	-
D	1 m	1 m	1 m	1 m	1 m	1 m
D1	r 62.5 m	r 62.5 m	-	-	-	-
D2	5 m	5 m	5 m	4 m	3.5 m	3 m
E	45 m	45 m	30 m	20 m	15 m	10 m
F	40 m	40 m	30 m	25 m	20 m	15 m
G*	65 m	-	-	-	-	-

Table 14: Traversing and slewing areas for N131

	N131/90°	N131/120°	r 50 m ≤ r min ≤ r 150 m			
A	r 53.5 m	r 54 m	r 75 m	r 100 m	r 125 m	r 150 m
B	r 61 m	r 61 m	r 82 m	r 106 m	r 130.5 m	r 155 m
B1	7.50 m	7 m	7 m	6 m	5.5 m	5 m
B2	3.50 m	3 m	3 m	2 m	1.5 m	1 m
C	r 74m	r 93 m	-	-	-	-
C1	6 m	4 m	4 m	3 m	2.5 m	2 m
C2	2 m	2 m	-	-	-	
C3	12 m	12 m	15 m	10 m	5 m	-
D	1 m	1 m	1 m	1 m	1 m	1 m
D1	r 66 m	r 66 m	-	-	-	-
D2	5 m	5 m	4 m	3.5 m	3 m	2.5 m
E	45 m	45 m	30 m	20 m	15 m	10 m
F	40 m	40 m	30 m	25 m	20 m	15 m
G*	75 m	-	-	-	-	-

The continuous lines depict the route of the truck. The dashed lines mark the areas covered by the vehicle and the rotor blade. The outer area covered is determined by the length of the rotor blade protruding at the rear.

The covered area (dashed) must be free of all obstacles and must be max. 20 cm above the sealed surface of the accessible road.

Due to the maximum steering angle of the rear axles of approx. 60°, curves that will be approached backwards must be constructed in a way that the respective turbine types are able to access the specified covered radii. The capacity of the normally deployed vehicles matches the loads that must be moved. The deployment of additional tractors and/or other vehicles, however, cannot be excluded due to local conditions. In case of pushing, different forces act on the vehicle and the load and the vehicle's steering behavior cannot be optimally influenced. Thus, accompanying damage to the road surface within the construction site cannot be excluded and must be repaired immediately or before access of successive heavy trucks. The exact values depend on the deployed vehicles and the individual conditions on site.

The maximum downhill slope or grade in curve radii/curve areas is < 2 %. A curve with downhill slope/grade shall be constructed in such a manner that the road surface is on an even level to protect the components from hitting the ground. The area within a radius of 50 m from the apex is in this case called the curve area and must be constructed as a level surface.

NOTE

If the minimum requirements for the curve construction cannot be met due to local conditions, it is possible to deviate from the minimum requirements by using different/special vehicles. These deviations may result in additional costs and must be agreed with Nordex in writing in advance.

3.3.2 Opportunity for turning and funnel lanes

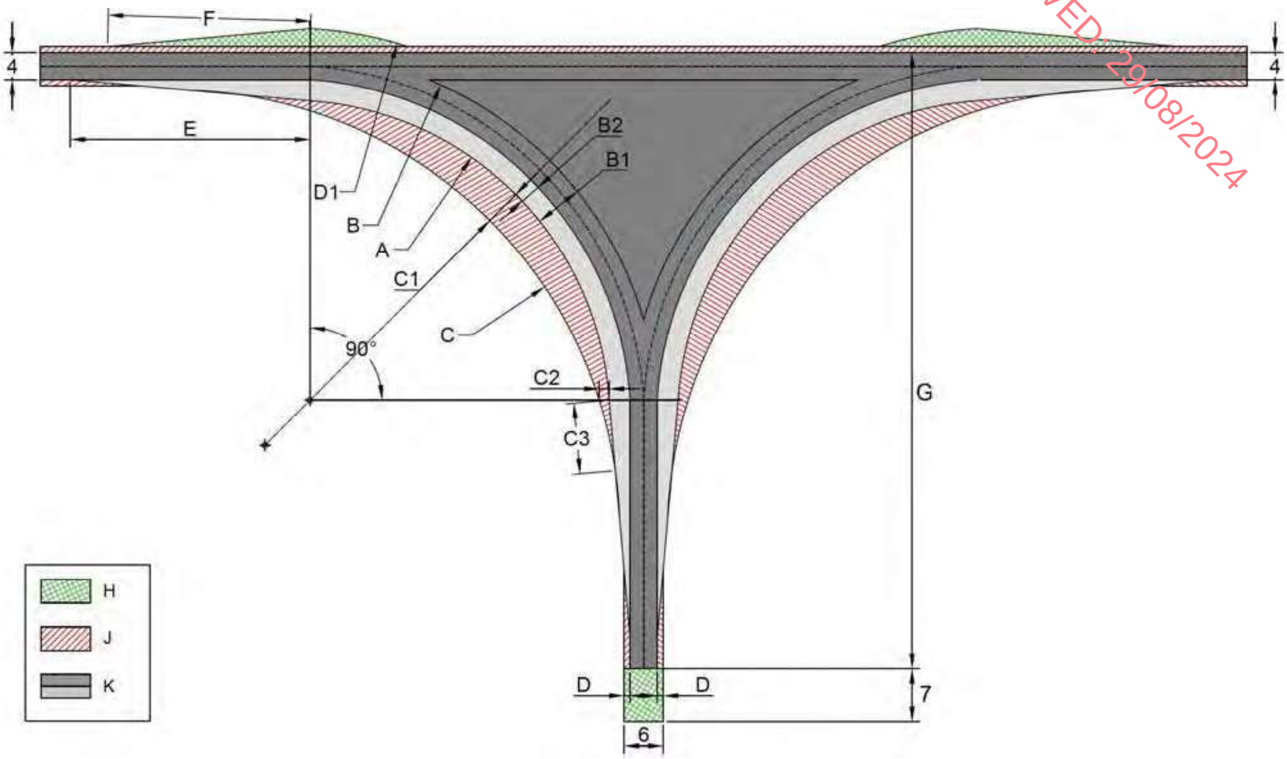


Fig. 16 Structural support of funnel lanes; see previous chapter for explanation of variables

* G – Depth of funnel lane = transport length + 5 m (N100=55 m; N117=65 m; N131=75 m)

Depending on the size of project and the access situation double funnel lanes enabling the vehicles to turn shall be constructed at strategic and central crossroads or preferably at access points to individual turbines.

These double funnel lanes shall enable the vehicles to turn and to leave the construction site forward. The lanes shall be located at strategic crossroads to avoid reversing over a distance of more than 500 m as these movements are very time-consuming and may affect the traffic on the construction site or the erection process. In addition, certain components must be transported to the respective site with forward or backward transport direction, depending on the used crane or assembly method. The transport and erection concept must be determined individually on site.

The dimensions of the funnel lanes result from the component length (see previous chapters) + 5 m = length of the funnel lane. The curve radii must be implemented as specified below. The width of the narrowest part (front side) is at least 4.5 m. If a funnel lane will be used as a parking area for more than one vehicle, the funnel lane must be expanded by 4.5 m per vehicle. Depending on the location it should be considered if four funnels in junction areas are required and feasible.

NOTE

The structural support of funnel lanes can be minimized depending on the transport and erection concepts. For example: In the case of a planned single blade assembly, the entrance funnel can be constructed according to the above-mentioned curve examples and the exit funnel for the empty vehicles with a radius of R35. A different construction method and the individual transport and crane concepts may result in additional costs, which have to be agreed with Nordex in writing in advance.

3.3.3 Road construction

Generally, the access roads shall be planned to enable secure transport for the respective wind turbine class and to achieve the load-carrying capacities described in Chapter 3.1 "Loads". For that purpose, the site-specific ground conditions must be taken into account. Planning and execution must be adapted accordingly. The structure described below serves only for illustration and does not release the ordering party from project-specific design and planning.

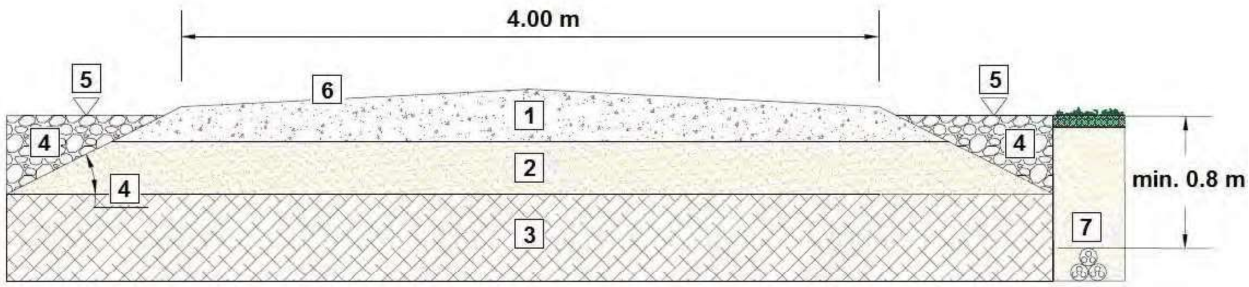


Fig. 17 Exemplary access road structure

1 Base layer compacted, gravel: 15-30 cm
2 Base compacted, 30 cm to 100 cm
3 Stable ground
4 Embankment 1: 2
5 Ground level
6 Camber ≤ 2 %
7 Cable trenches

- Once the roads have been completed, quality inspections must be carried out, see chapter 3.3.6 "Quality inspections, access roads and crane hard standing areas".
- Cable trenches must only have the corresponding depth along the access road. If cables must cross the access road, conduits must be laid at the corresponding locations. The cable trenches must be embedded and filled with adequate material in the appropriate design in accordance with Nordex requirements.

- On straight, even road sections (project-specific), an accessible width of 4 m is sufficient. The width must not fall below this value. Otherwise, the specified minimum requirements apply. In this context, the areas alongside the roadway must be stable and constructed with a minimum slope of 1:2. It is essential that the load transfer angle is observed.
- A minimum access road width of 4.5 m is required if the inclination is greater than 8 % and for road sections where reversing in a loaded or empty state is required.
- Instead of gravel, base and top layer may be made of broken bricks or concrete (free of other demolition waste)
- Existing asphalt/concrete roads with a smaller accessible width than specified above must be expanded to the appropriate width on one side.
- The rubble and gravel base layers may consist of mixed building materials with a grain size of 32 mm, 45 mm or max. 56 mm. The fine content (<0.063 mm) must not exceed 5 % and 7 % in the assembled state.
- All layers and the subsoil must be compacted using proper machinery to allow for heavy trucks
- Even road surface
- Proper drainage for all access roads must be ensured (cross slope of 1 to 2 %)
- Proper water transport, e.g., in lateral trenches or under access road junctions, must be ensured in order to permanently prevent undercutting, erosion, cavity formation and landslides.
- If road sections of the internal access roads are below the level of the surrounding fields, etc. suitable measures to drain the roads must be taken.
- Before starting road construction, a project- and site-specific design/execution plan for the access roads must be prepared. In doing so, the detailed requirements specified by the structural engineer, geotechnical engineer, haulage contractor and by Nordex must be fulfilled. If the required measures are not implemented, this could cause delays and additional costs for the use of other adequate transport methods.
- Access roads and crane hard standing areas must have the required load carrying capacity and be accessible for heavy-duty vehicles under any possible weather conditions during the entire construction period. Occurring damages to the road surfaces must be repaired by the ordering party immediately.
- Crawler cranes may require special transport and travel roads. Track width of up to 12 m might be necessary.

3.3.4 Turnouts

Turnouts serve as parking areas for arriving trucks or already unloaded trucks and as turnouts for oncoming vehicles. These turnouts must ensure an unobstructed accessibility of assembly areas during the delivery and erection stage and help to maintain smooth traffic flow during the entire construction phase. The positioning of these areas must individually be agreed upon with Nordex for each project.

The following two illustrations show an exemplary construction of the parking and turnout areas. These areas can be temporarily supported with gravel or laid out with traversable bolted panels. The lateral inclination must not exceed 2 %. Depending on the layout of the internal wind farm infrastructure, the parking and turnout areas can be integrated into the auxiliary crane areas (crane hard standing area for the crane jib installation), see fig.19. Turnouts must be arranged in such a way that they can also be used as resting areas for empty vehicles.

In general, at least one turnout/parking area near the entrance to the wind farm must be planned. In this way, arriving heavy trucks can leave the public road and can be individually guided to the respective WT site at daybreak/when starting work.

For longer one-lane main access roads (from approx. 750 m), turnouts (parking bays) of the dimensions L=60 m (N100), L=70 m (N117), L=80 m (N131) must be provided every 500 m in addition to the existing main access road, enabling oncoming vehicles to move aside. This applies to all vehicles.

Due to the specific location and design of the access roads, turnouts must be provided for access roads to assembly areas where the access road is used for traveling to and from the site (dead end). These turnouts must be built on one side, in longitudinal direction, with the dimensions L=180 m (N100), L=210 m (N117) or L=240 m (N131), in addition to the existing roads. This will allow other vehicles such as rescue services to access the site unobstructed during the erection and delivery stage.

If the access road to the WT site is shorter than the required length of the turnout, the length can be divided into up to three sections of 60, 70 or 80 m each and, for example, run along the left and right of the entrance. The extension of an access road behind or past the assembly area is recommended only for one vehicle length (approx. 60, 70 or 80 m).

Parking with direct connection to the WT site for at least 3 rotor blade vehicles must be ensured.

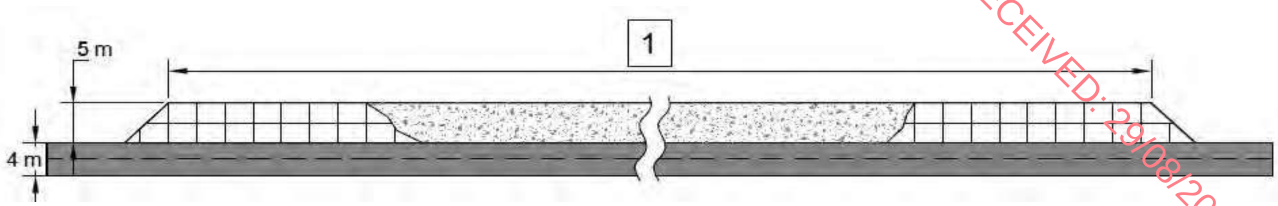


Fig. 18 Normal turnouts (without integration into the auxiliary crane areas)

1 Length of the turnout:
N100: 3 x 60 m or 180 m
N117: 3 x 70 m or 210 m
N131: 3 x 80 m or 240 m

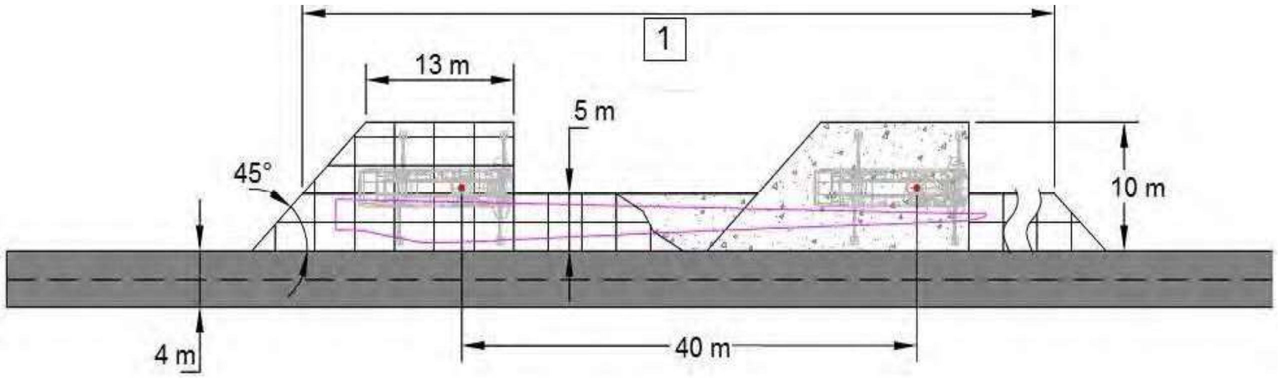


Fig. 19 Turnouts with integration into the auxiliary crane areas

1 Length of the turnout:
N100: 3 x 60 m or 180 m
N117: 3 x 70 m or 210 m
N131: 3 x 80 m or 240 m

3.3.5 Storage areas and site office

The following sketch shows a general illustration of a Nordex site office, which must be designed specifically for each project:

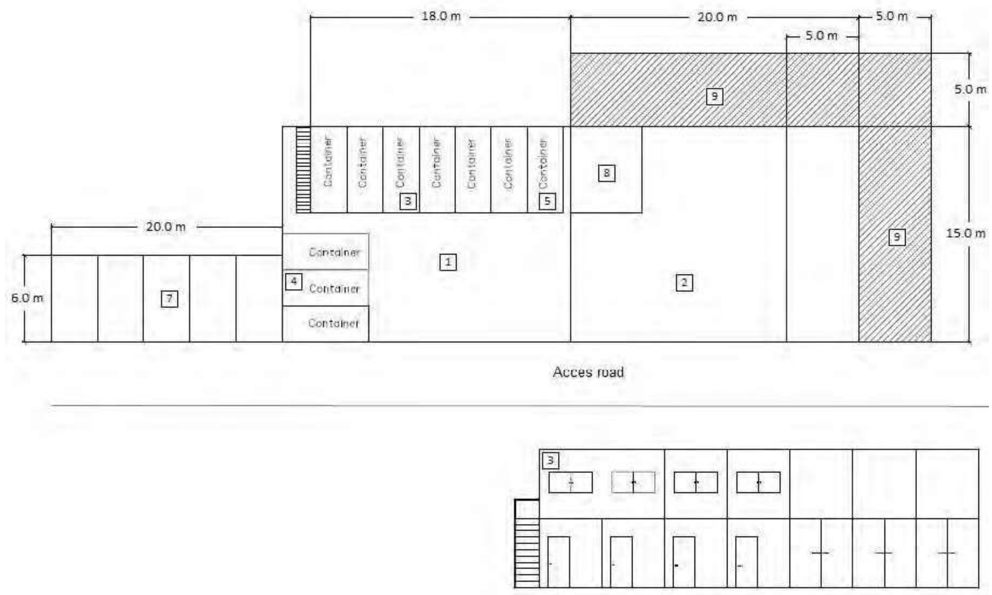


Fig. 20 Nordex site office (example)

1 Office area & assembly point
2 Storage/handling area for small components & material
3 Container village – two stories
4 Containers – erection team / crane team & optional
5 Storage container for hazardous substances
6 Container village staircase
7 Car parking area
8 Storage area for tank system & garbage container
9 Extension area for TIT or >10 WTs

Office area requirements:

- The area must be outside of the danger area (wind turbine height).
- It should be located in the area of the wind farm entrance (main entrance) on a straight road section, at which all transports enter the wind farm (entry check, check-in, check-out and driver guide point).
- The construction is carried out in the same way as the access roads (see chapter 3.1 “Loads”)
- The office area can be constructed with an inclination of up to 2 %.
- The entire office area is a temporary construction for the entire project phase and can be deconstructed after wind farm commissioning.

The client must provide an area of 720 m² to accommodate the following equipment and facilities:

- Nordex office – 20-ft container
- Construction company office – 20-ft container
- Office for meetings – 20 ft container
- Generator with drip tray
- Recycling
- Free space for material on euro-pallets (14 m x 2.5 m)
- Restroom
- Empty area for material (fenced if applicable (recommended)): 14 m x 2.5 m)
- 4x 20 ft material container (2x for material/1x for cables/1x for storing material in a dry and heated area)
- At least eight parking spaces for cars

3.3.6 Quality inspections, access roads and crane hard standing areas

The customer is responsible for performing the following minimum required quality inspections of access roads and crane hard standing areas in the form of a soil investigation report, including analyses of load-carrying capacity and bearing capacity. The inspection results must be submitted to Nordex no later than four weeks before delivery starts:

Quality inspections	**Minimum number/ comments**
Degree of compaction (Dpr) according to DIN 18127 (or comparable local standard) of the access roads in layers (bed, base layer, top layer)	1 test (every 500 m)
Degree of compaction (D_{pr}) according to DIN 18127 (or comparable local standard) of the **Crane hard standing area** layered (substructure, base layer and top layer)	4 tests (per crane hard standing area)
Static plate load test according to DIN 18134* (or comparable local standard) of the **access roads** in layers (bed, base layer, top layer)	3 tests (every 5000 m²)
Static plate load test according to DIN 18134* (or comparable local standard) of the **crane hard standing areas** in layers (bed, base layer, top layer)	2 tests (per crane hard standing area)

* The following conditions must be met:

- Ev2 ≥ 100 MN/m² and Ev2/Ev1 ≤ 2.3
- If the Ev1 value has already reached 60 MN/m² the ratio Ev2/Ev1 can also be higher.

All test results must be thoroughly documented in a professional manner, illustrated with tables and diagrams and submitted to Nordex. The positions and heights of the test points must be presented in diagrams. The soil profile of access roads and crane hard standing areas also require neat presentation.

NOTE

During maintenance the load-carrying capacity of the access roads and the crane hard standing areas must be regularly checked and verified in accordance with the above-mentioned quality inspections. If a component must be replaced, the quality inspections incl. the verification must be performed before commencing the transport. Any repair measures must have been completed before commencing the crane movement

3.4 Friction cable guying

Provisions must be made to allow for enough space for installing the friction cable guying during assembling and disassembling works on tubular steel towers. Two guyings are required which must be placed in a 90° angle from one another. To guide the ropes for the frames, two flat surfaces plus a 4 m wide access road are required in defined areas. These areas must be at least 3 x 3 m in size (10 x 10 m clearance/working area).

For each specific construction site, the responsible person will determine which of these positions does not conflict with lifting plans. Rotating the nacelle by 180°, meaning that the hub is positioned behind the tower when viewed from the crane hard standing area, must be coordinated and agreed with the local crane company, for example.

Requirements deviating from general provisions may be possible for specific projects after such specifications have been reviewed and approved by Nordex.

This applies to the following towers:

Table 15: Guying radii of the towers

Tower	Guy angle [m]
N131/3600 TS99	45
N131/3600 TS106	45
N131/3600 TS114 N131/3900 TS114	45
N117/3600 TS120	45
N131/3600 TS120 N131/3900 TS120	45
N131/3600 TS120 N131/3900 TS120	45
N131/3900 TS105	55

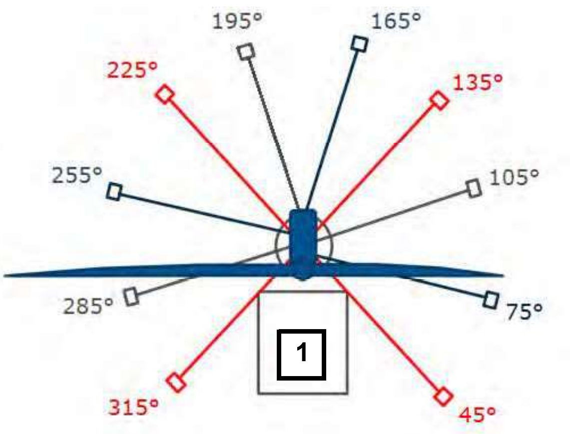


Fig. 21 Top view, general case, erection variants for frames

1 Crane hard standing area

3.5 Public roads

The client is always responsible for access roads from the port of destination or a suitable motorway exit to the construction site. Any necessary structural measures must also be planned, approved and executed by the client.

Here, Nordex can be of support when performing feasibility studies and listing required constructive measures. Depending on the complexity of the access roads, it may be necessary to obtain a test permission at an early stage or perform a “dummy run” prior to starting the heavy duty transports.

4. Crane requirements

One main crane and at least one auxiliary crane are required for the wind turbine erection. The auxiliary crane must be able to change position several times before, during and after wind turbine erection. The given masses take the variants with the maximum weight into account.

The required hook height is:

- Towers without tuned mass damper: Hub height + 14 m
- Towers with tuned mass damper: Hub height + 20 m

The main crane radius is at least 15-30 m (depending on the crane type)

The auxiliary crane radius is 6-12 m (depending on the crane type)

The weight specifications include the maximum weight tolerances of the components:

Hub height	**75 m**	**85 m**	**100 m**
Wind turbine type	N100	N100	N100
Performance class [kW]	3300	3300	3300
Main crane - Maximum hook load - Maximum hook load at hub height Star assembly Single blade assembly	69 t 69 t 62 t	69 t 69 t 62 t	73 t 69 t 62 t
Auxiliary crane Required hook load	35 t	35 t	40 t

Hub height	**91 m**	**106 m**	**114 m**	**120 m**	**141 m**
Wind turbine type	N117	N117	N117	N117	N117
Main crane - Maximum hook load for an individual module (single blade assembly) - Maximum hook load at hub height Star assembly Single blade assembly	75 t 68 t 64 t	80 t 68 t 64 t	71 t 68 t 64 t	78 t 68 t 64 t	68 t 68 t 64 t
Auxiliary crane Required hook load	40 t	40 t	40 t	40 t	40 t

Hub height	84 m	99 m	106 m	114 m	120 m	134 m	164 m
Wind turbine type	N131	N131	N131	N131	N131	N131	N131
Main crane - Maximum hook load for an individual module (single blade assembly)	69 t	68 t	80 t	71/76 t*	78 t	90/80 t**	90 t
- Maximum hook load at hub height Star assembly Single blade assembly	 92 t 67 t	 92 t 67 t	 92 t 67 t	 92 t 67 t	 92 t 67 t	 90/92 t** 67 t	 90 t 67 t
Auxiliary crane Required hook load	40 t	40 t	40 t	40 t	40 t	40 t	40 t

* maximum weights for N131/3600 and N131/3000 Controlled or N131/3900

** maximum weights for N131/3300 or N131/3600, N131/3000 Controlled and N131/3900

5. Crane hard standing area

The crane hard standing area must be planned and laid out according to the local conditions and the cranes that are used. The crane hard standing area must withstand the soil pressure of the crane outriggers and tracked vehicles. The amount of the surface pressure depends on the max. weight of components and size of the crane used (mobile crane, crawler crane) and must be at least 250 kN/m².

The entire area of the crane hard standing area must be level, must not have any slope and must be planned such that the height difference shown in the respective turbine-related foundation plan between hard standing area and foundation top edge is not exceeded (tubular steel towers: 1.10 m, hybrid towers: 1.80 m). If these values are exceeded, larger, more cost-intensive crane technology is required. The top foundation edge should not be less than 0.5 m below the top terrain edge or top edge of the crane hard standing area. The height difference shown in the foundation plan is also part of the hub height.

In the case of hybrid towers, the transition (access ramp see fig.24) between the crane footprint and the backfilled foundation must be made with a maximum slope of 10° in a gravel construction with a load-bearing capacity of 120 kN, so that construction site vehicles can access the foundation area for the assembly. The ramp must be attached in a way that the main crane can operate unrestricted and the emergency roads are also maintained unrestricted. For tubular steel towers, a staircase see fig.25 (table + figure (item 4a/4b) may be constructed instead of a ramp.

The crane hard standing area and the erection and working area (e.g. clearance) of the crane must be free of obstacles, which might interfere with the erection and operation of the crane (see following drawings). The length of the rotor blades and the space for the assembly of the crane jib must in particular be considered for crane operation.

Excavated material must be stored only behind the foundation (see fig.22) or outside the illustrated assembly areas and the curve areas including slewing areas (see chapter 3.3.1 “Curves”).

The transformer substation must not be placed on the crane hard standing area or the assembly area of the crane jib. To prevent dirt from entering the wind turbine, access to foundation and the ground must be compacted and covered with gravel to ensure a dry and clean surface.

A walkable working area, approx. 2 m wide, must be provided directly around the foundation. The nacelle must only be placed on the crane hard standing area or, using crane mats/wooden supports, on suitable stable ground.

For the assembly of the crane jib of lattice boom cranes, a long, level area with a minimum width of 5 m is required that can be accessed with 8 t. It must be gravel or covered with bolted panels. The minimum length is shown in the following examples, depending on the tower height. The auxiliary crane must be able to move parallel to the entire length of the assembly area.

The assembly areas overlap with the compacted areas of the access roads and the crane hard standing areas. These areas are dashed and marked as aisles or storage areas.

The crane hard standing areas can be adapted to the individual site conditions for a particular project. The required space can be optimized by using adequate crane, transport and assembly technology. Any deviations from the following examples of crane hard standing areas may cause additional costs. Individual modifications or transport/assembly/crane concepts must be agreed with Nordex in writing in advance.

To ensure a smooth assembly process, storage areas for all components must be planned/provided at all crane hard standing areas. In the examples below these areas are shown as storage areas for rotor blades, for example. Tower sections can also be deposited outside the paved crane hard standing area on adequate supports. Any deviation leads to higher logistics costs due to added effort. Furthermore, any deviation must be coordinated individually with Nordex in advance. **Notice:** No components must be deposited in the jib assembly area that prevent the sudden lowering of the crane jib.

At forest locations ore sites with demanding topography where no storage areas can be provided, at least one central area must be provided where components can be deposited. The auxiliary crane areas may be stabilized with gravel or temporary with bolted panels. Alternatively, two crane hard standing area must be dimensioned in a way that tower sections and rotor blades can be deposited on the crane hard standing area and/or in the area for the jib assembly. In these cases, higher costs must be expected due to greater logistics effort.

Sufficient space for at least two Nordex erection containers must be provided (for power generator and tools) as well as additional space for a Nordex material container for temporary material storage, garbage containers, staff containers, construction vehicles, etc.

The access roads to the wind turbine must always be kept free for ambulance and rescue, assembly and site vehicles. The escape paths must be designed for crane hard standing areas according to the following examples. A reliable escape route concept must be presented prior to commencing construction.

The following examples show crane hard standing areas for forest and open country for turbines up to 170 m tower height. The detailed layout for the specific site must be planned after the site has been inspected.

In addition to the areas shown in the examples, a clear assembly area for the rotor (for star assembly, N117 only) is also required. This area depends on the local conditions and must be specified in cooperation with Nordex. Sufficient space for at least two Nordex erection containers must be provided (for power generator and tools) as well as additional space for a Nordex material container for temporary material storage, garbage containers, staff containers, construction vehicles, etc.

The following two examples show the design of a modular crane hard standing area (see fig.22, optimized forest crane hard standing area and see fig.23, optimized crane hard standing area for unobstructed locations). The examples shown illustrate the optimum crane hard standing areas including all modules (storage areas). Dependent on location, topographical conditions or the available area, individual modules might be removed or moved. It should be noted that movements might result in additional costs if the modules are not within the handling area of the large crane. For the turbine-specific dimensions, refer to the Table below, see “Table 16: Values for crane hard standing areas”.

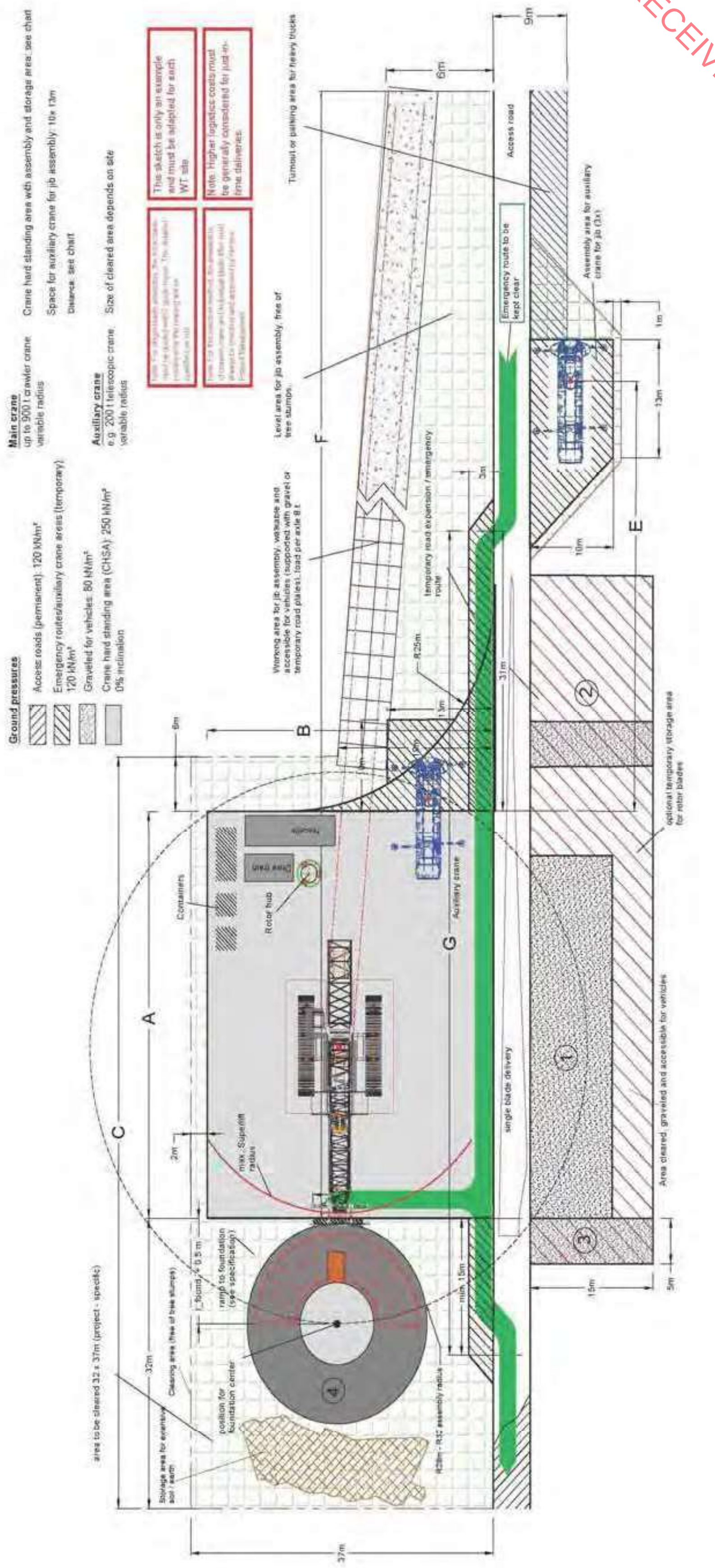


Fig. 22 Optimized crane hard standing area for forest sites (single blade assembly) for WTs of up to 170 m hub height

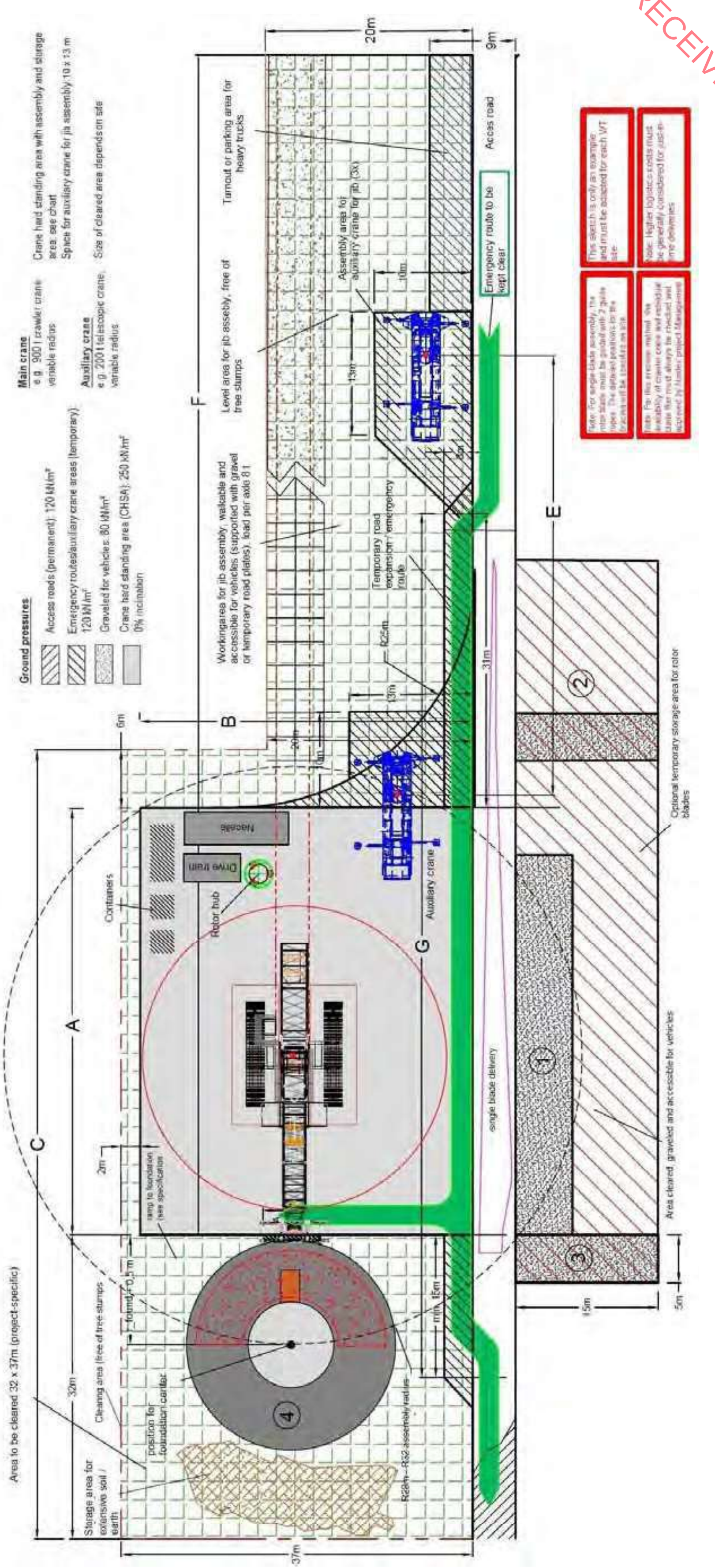


Fig. 23 Optimized crane hard standing area for open country sites (single blade assembly) for WTs of up to 170 m hub height

Alternative design variants:

- Within the wind farm, a central area at the wind farm entrance (preferably open space) may be chosen. If necessary, panels must be laid out for the auxiliary cranes; the components may be deposited on wooden supports. Surface damage will be inevitable.
- The blade storage areas may be integrated into the jib assembly areas (in the area of the first two auxiliary crane pockets / the depth here corresponds approximately to the required depth and length “2”). In this case, at least two crane hard standing areas must be provided for this purpose (The components can be deposited only where either no WT has yet been erected or where a WT has already been erected; the deposited components must not prevent the jib assembly/disassembly).

The working areas around the tubular steel tower must be constructed as follows:

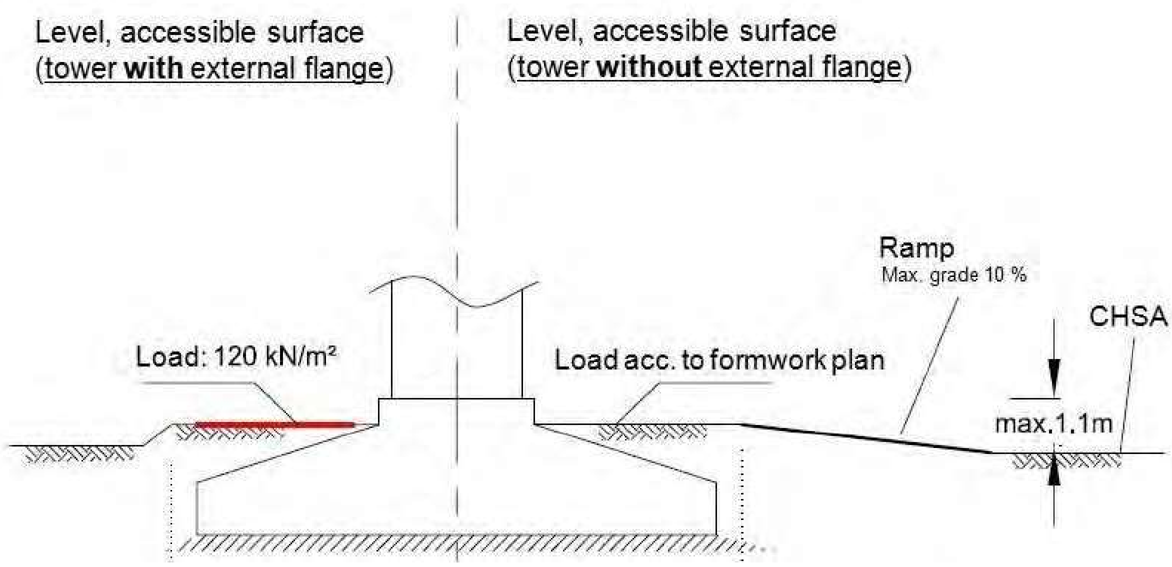


Fig. 24 Area around the tower – sectional view

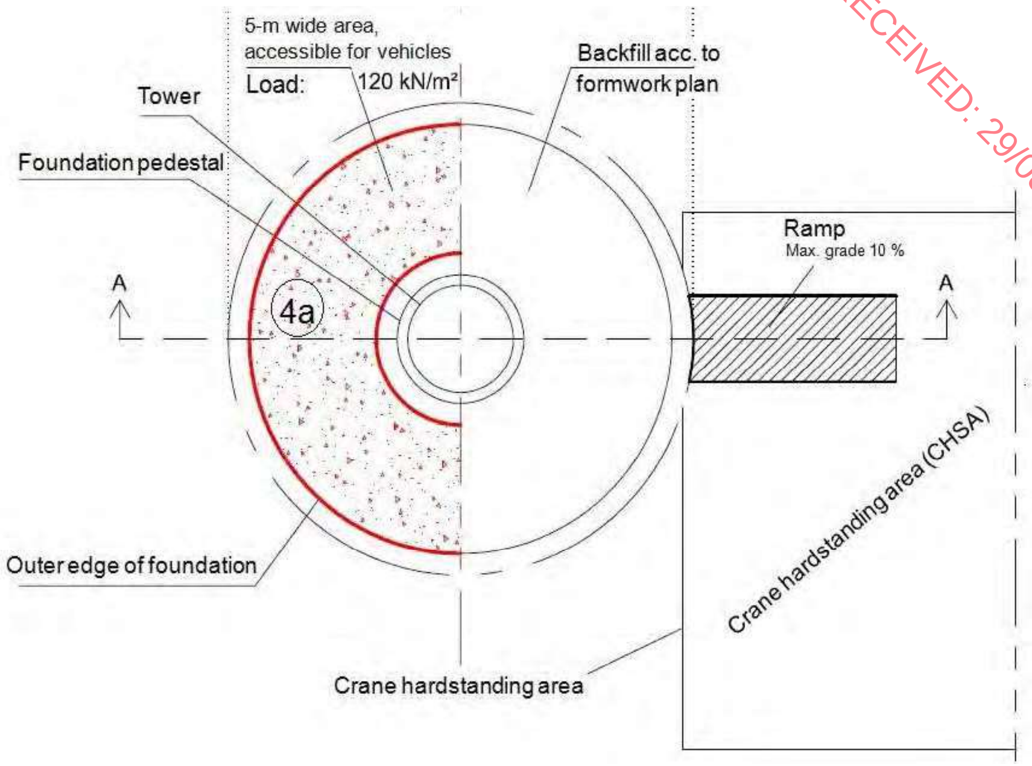


Fig. 25 Area around the tower (tubular steel tower) – top view

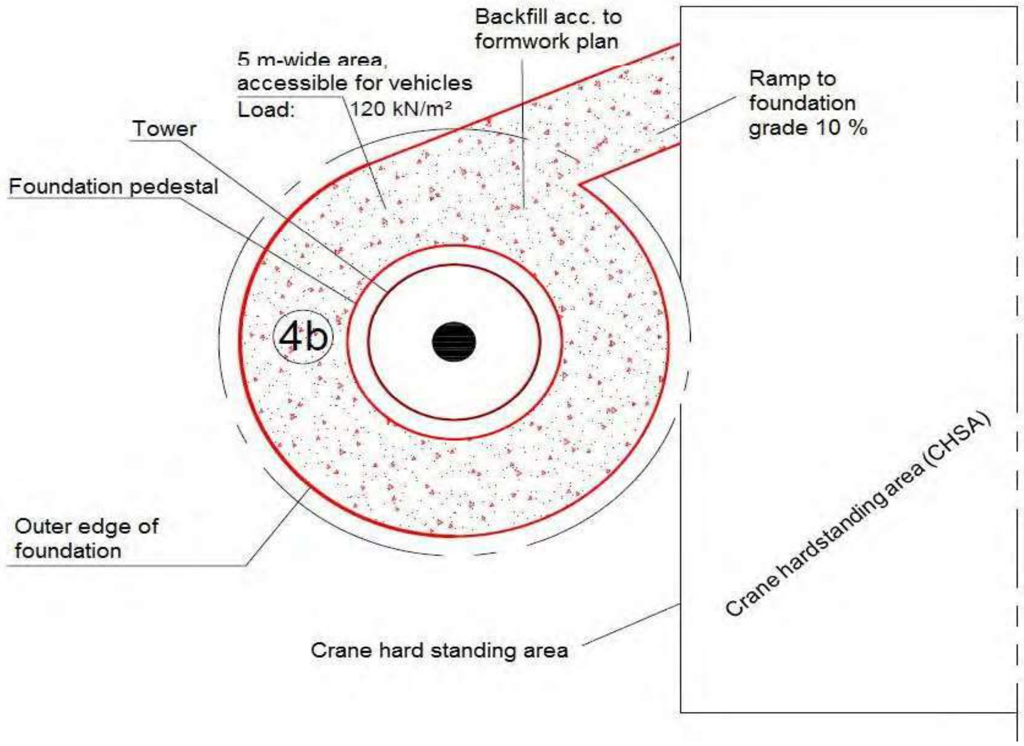


Fig. 26 Area around the tower (hybrid tower) – top view

Table 16: Values for crane hard standing areas

Crane hard standing area		**R100 TS99 R99 TS76 TS91 TS84 R85 R75**	**TS120 TS114 TS106**	**PH164 TCS141 TS134 TCS134 PH134**
A (Length crane hard standing area)	m	40	45	45
B (Width crane hard standing area)	m	25	30	35
B1 (width of optional tower storage space) only for locations on open space)	m	10	15 - 20	10
C (length of clearing area) (for crane hard standing area only)	m	74	74	74
E (distance of auxiliary crane pockets / each to the center point)	m	40	40	40
F (length of the jib assembly area / measured from the transition of the foundation edge / crane hard standing area)	m	110	130 - 160	180
G (length of emergency lane / it must be possible to drive around the longest vehicle (NR 65.5 (N131) / blade length 64.7 / transport length 73.5m / current worst-case assumption))	m	70/80	70/80	70/80
1 (pre-assembly area / handling area)	m	x	x	6 x 40
2 (blade storage area / optional)*	m	12 x 50/ 12 x 60/ 15 x 67	12 x 60/ 15 x 67	12 x 50/ 12 x 60/ 15 x 67
3 (blade fingers / support points for the rotor blade transport frames (distance in acc. with table, item 2.4))	m	5 x 12/ 5 x 15	5 x 12/ 5 x 15	5 x 12/ 5 x 15
4a (staircase to the foundation / table: inclination up to 10°: gravel / 11°-30° handrail + graveled steps / 31°-45° = steps + handrail	m	required	required	required
4b (ramp to the side of the crane hard standing area on the foundation/gravel on the gravel/accessible foundation area / load capacity 120 kN)	m	required	required	required

* If present, no additional costs, if not present directly at the crane hard standing area: Additional costs for logistics (driving around the components / within the wind farm) must be included in the calculation.

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