Sales document

Transport, access roads and crane requirements for the K08 delta wind turbines N117/3600, N131/3600 IEC S and N131/3900 IEC S

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Technical modifications

This document was created with utmost care, taking into account the currently applicable standards. However, due to continuous development, the figures, functional steps and technical data is subject to change without prior notice.

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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 (N117 and N131 with the specified hub heights) and the component dimensions for the design of transport equipment and cranes.

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 evaluated and planned individually regarding 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, especially with regard to see chapter 3.2 "Slopes and vertical radii", additional safety measures may be necessary, which must be agreed with Nordex in writing 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 to 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.

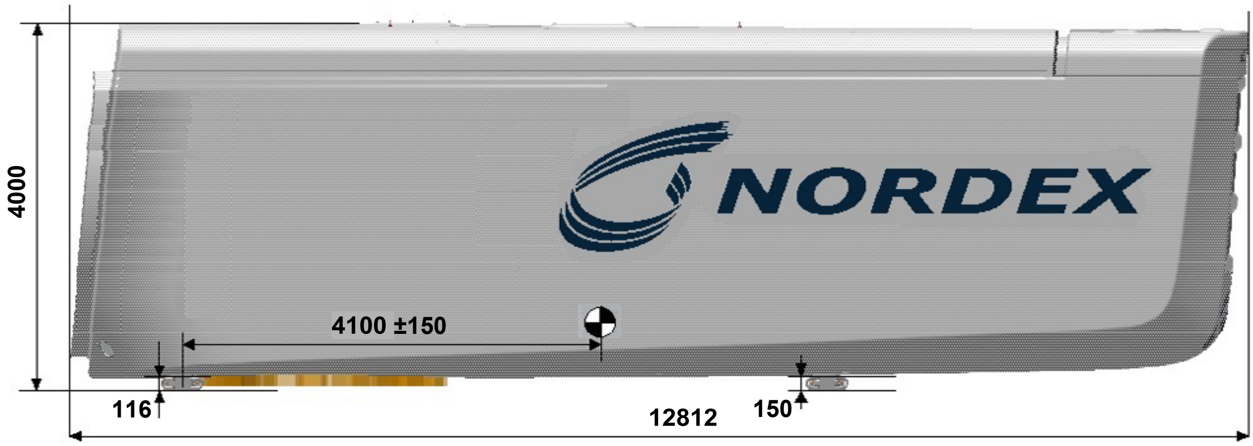


Fig.1 Nacelle (view from the left) with transport supports

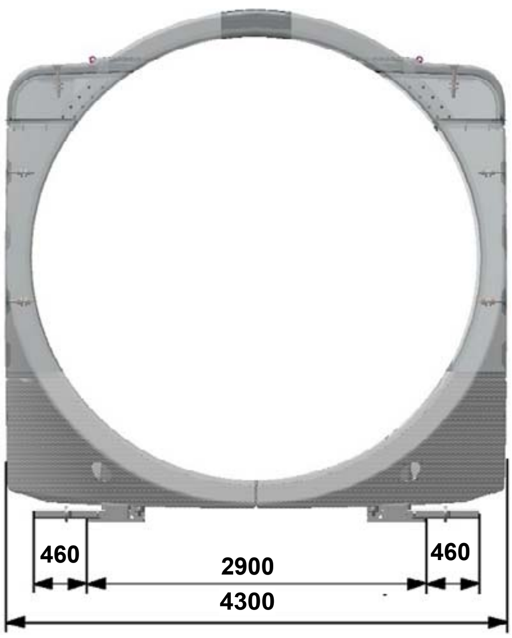


Fig.2 Nacelle (front view) with transport supports

2.2 Drive train

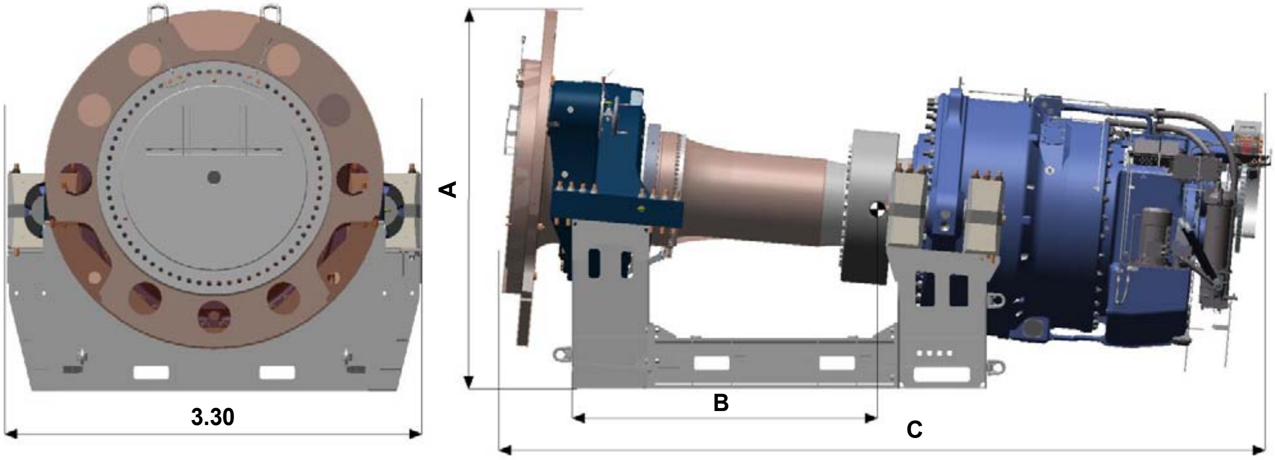


Fig.3 Dimensions of the drive train on the transport frame (all dimensions in m)

	N117	N131
A	2.95	3.00
B	2.00-2.40	1.9-2.3
C	6.10-6.15	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 N117

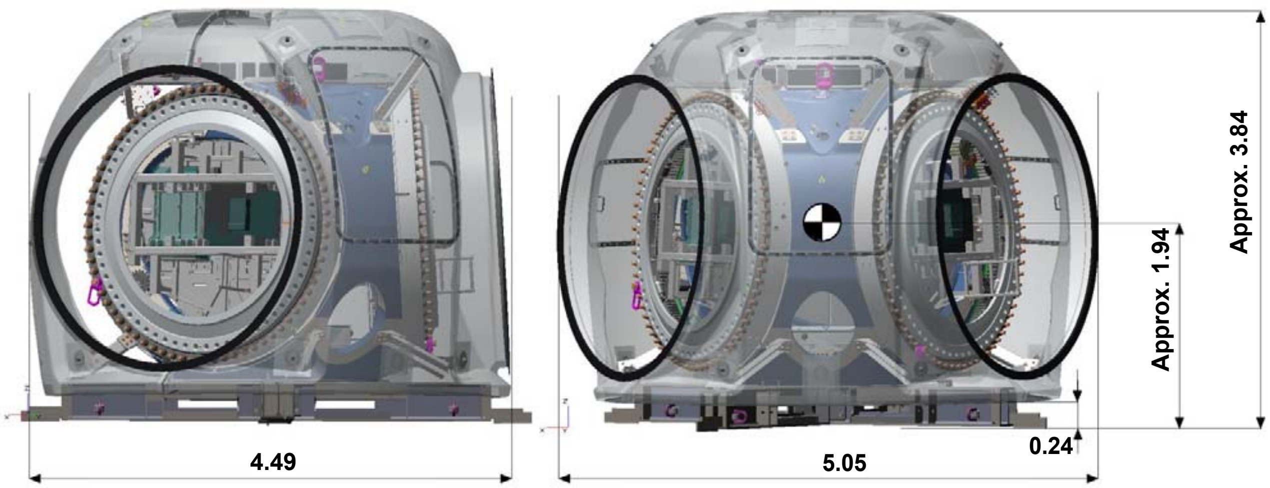


Fig.4 Rotor hub N117 on transport frame (dimensions in m)

N131 rotor hub

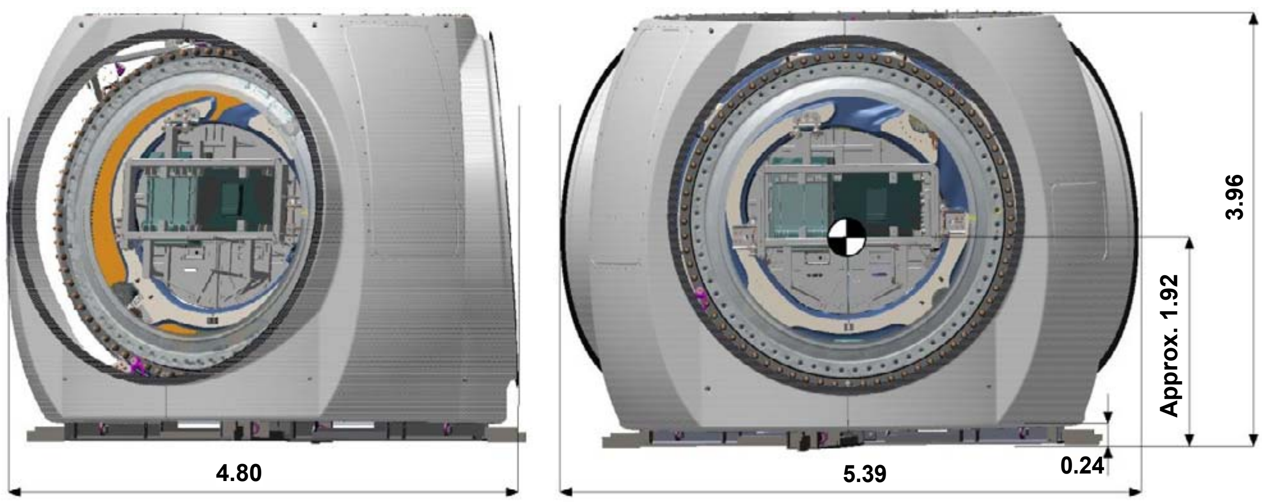


Fig.5 Rotor hub N131 on the transport frame, ready for transport (dimensions in m)

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.

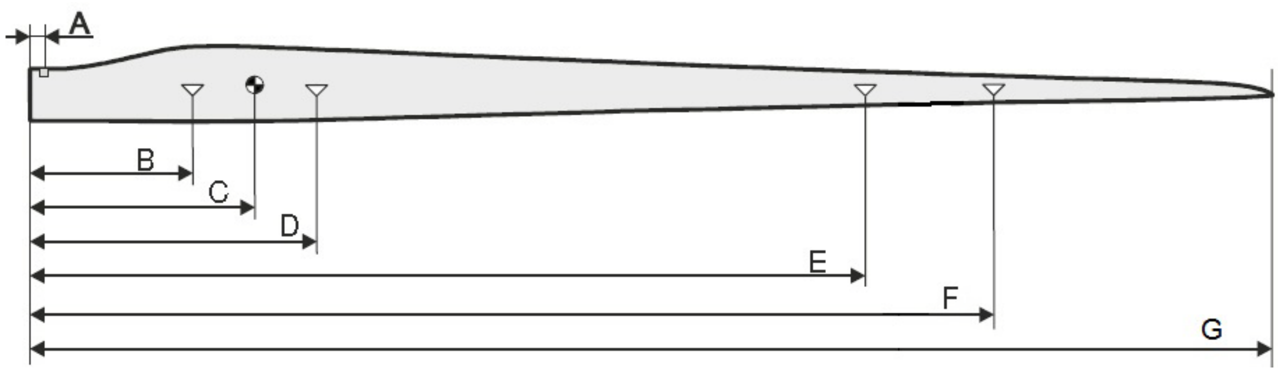


Fig.6 Blade transport dimensions – side view

Rotor blade		**NR58.5**	**NR65.5**
A	Lifting point at the root	0.32/1.0[1]	0.30/0.9[1]
B	Lifting point for single blade assembly (SBA)	On request	
C	Center of gravity	15.90	17.80
D	Lifting point for SBA	On request	
E	Start of handling area	38.00	42.50
F	End of handling area	43.00	53.50
G	Length	57.60	64.70
J	Transport width		4.20
	Road transport	3.36	-
	Sea transport	3.22	-
K	Transport height		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

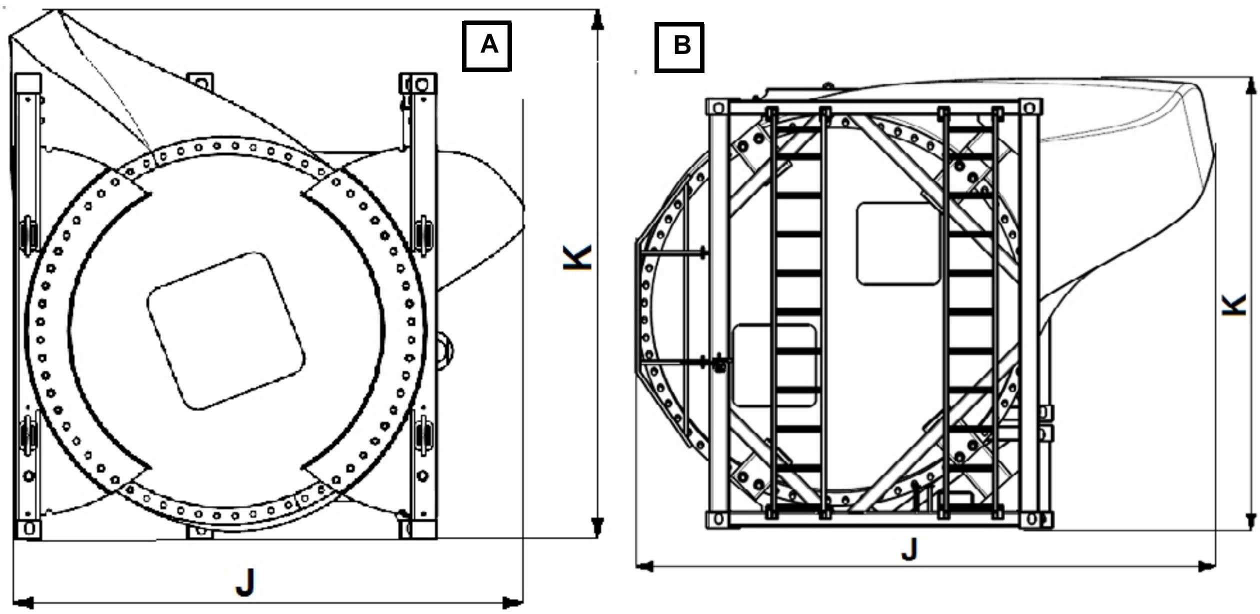


Fig.7 Blade transport dimensions, view from the blade root; example for sea transport (A) and road transport (B)

2.5 Weights of components on crane hook

2.5.1 Weights during transport (with transport frame)

Nacelle	N117	N131
Height / width / length (without roof structures)	4.00 m / 4.30 m / 12.81 m	
Weight of nacelle without drive train*	Max. 62.4 t	
Weight of drive train only*	Max. 66.9 t	Max. 69.8 t

Rotor hub	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. 36.8 t	Max. 45.8 t

Switch cabinet (Bottombox)	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 during erection (without transport frame)

Nacelle	N117	N131
Height / width / length (without roof structures)		
Weight of nacelle without drive train*	Max. 61.7 t	
Weight of drive train only*	Max. 63.7 t	Max. 66.6 t

Rotor hub	N117	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. 35.1 t	Max. 44.9 t

Rotor blade	N117	N131
Weight per blade*	Max. 11.7 t	Max. 15.7 t

Transformer	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. 0.67 t
Drive train	Approx. 3.2 t
Rotor hub	Approx. 1.7 t
Rotor blade (blade root/tip) depending on transport method	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

Transport frames nacelle 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.

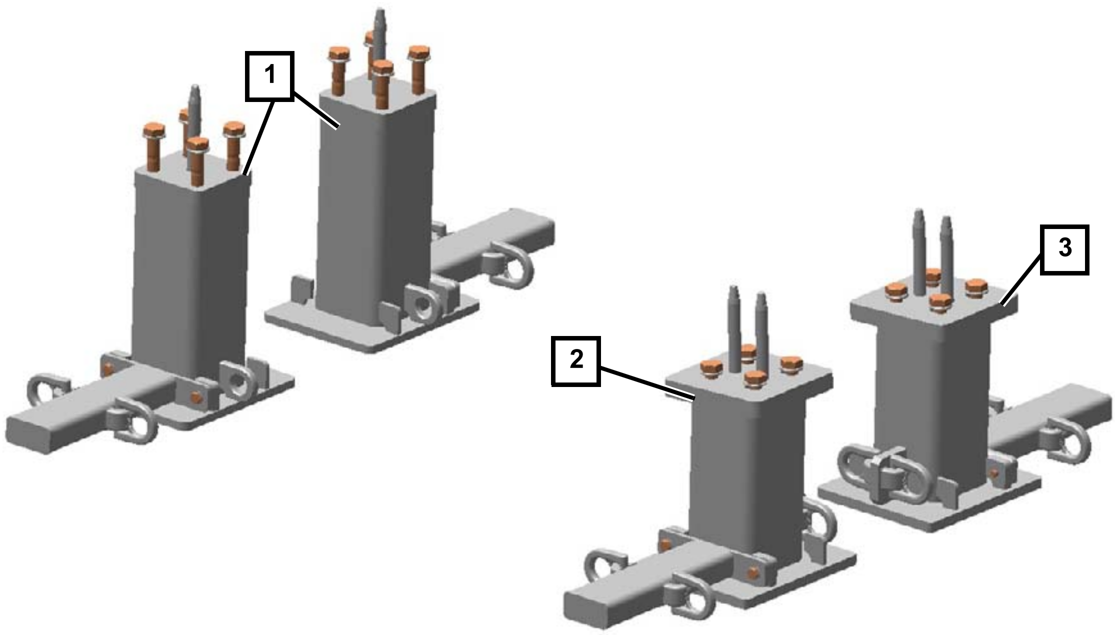


Fig.8 *Transport supports – nacelle*

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

Transport frame drive train N117 and N131

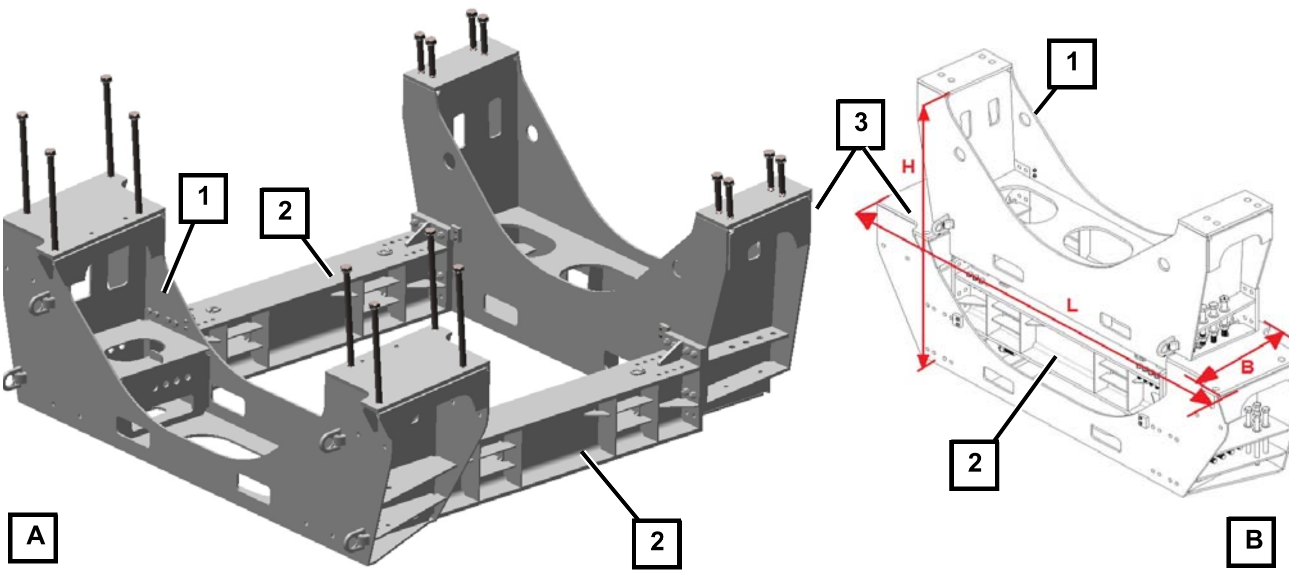


Fig.9 *Transport frame drive train and fasteners (A) and assembled in space-saving way for return transport (B)*

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 joined in a space-saving manner 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 N117 turbines it may also be possible to use the old transport devices with the dimensions H: 2.24 m; W: 2.30 m; L: 4.31 m for 3 folded and stacked frames.

Rotor hub transport device

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.

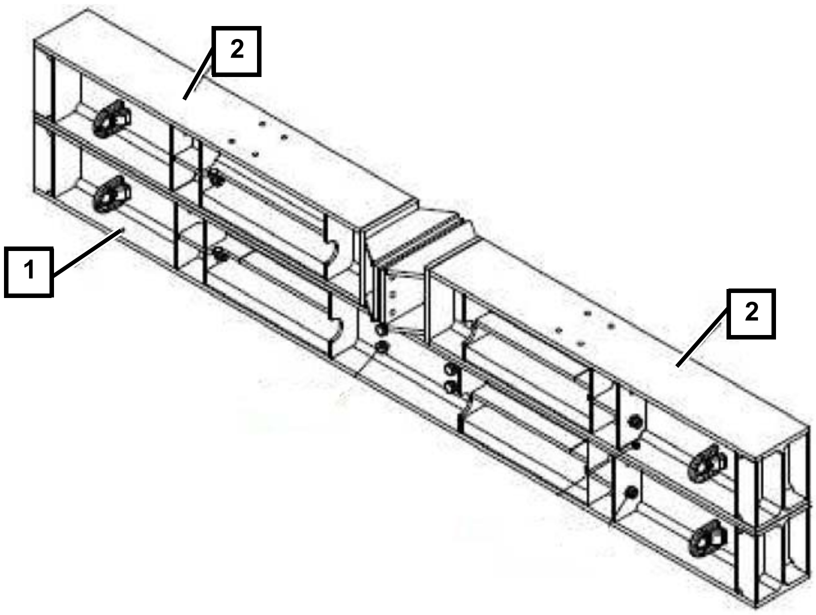


Fig.10 Rotor hub transport frame assembled for return transport

1 Beam, long
2 Beam, short

Note: For 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 N117/3600 towers

Hub height		91 m	106 m	120 m	141 m
Tower type		Tubular tower TS91	Tubular tower TS106	Tubular tower TS120	Hybrid tower TCS 141
Tower section TOP Length Ø top Ø bottom Weight	 m m m t	 35.06 3.26 4.02 52.4	 35.00 3.26 4.25 58.5	 34.21 3.26 4.02 54.8	 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 67.6	-
Tower section MID2 Length Ø top Ø bottom Weight	 m m m t	-	 29.92 4.25 4.26 76.5	 21.04 4.26 4.27 63.7	-
Tower section MID1 Length Ø top Ø bottom Weight	 m m m t	 29.95 4.02 4.02 63.8	 22.54 4.26 4.28 80.0	 18.12 4.27 4.27 74.1	-
Tower section Bottom Length Ø top Ø bottom Ø T flange Weight	 m m m m t	 22.83 4.02 4.04 4.30 74.8	 15.38 4.28 4.05 4.30 80.0	 13.53 4.27 4.05 4.30 78.1	 29.95 4.29 4.29 4.29 62.9

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 %.

2.8 N131/3600 and N131/3900 towers

Hub height		84 m	106 m*	112 m*	114 m	120 m	134 m	134 m
Tower type		Tubular tower TS84	Tubular tower TS106	Tubular tower TS112	Tubular tower TS114	Tubular tower TS120	Tubular tower TS134	Hybrid tower TCS134
Top section (TOP) Length Ø top Ø bottom Weight	 m m m t	 34.02 3.26 4.02 50.2	 35.0 3.26 4.23 58.5	 35.00 3.26 4.25 55.5	 30.00 3.26 4.02 46.8	 34.21 3.26 4.02 54.8	 34.02 3.26 4.02 53.8	 30.91 3.26 4.29 45.0
MID4 section Length Ø top Ø bottom Weight	 m m m t	-	-	-	-	-	 29.41 4.02 4.26 64.8	-
MID3 section Length Ø top Ø bottom Weight	 m m m t	-	-	 29.92 4.25 4.26 77.0	 25.00 4.02 4.26 53.2	 29.94 4.02 4.26 67.6	 24.01 4.26 4.27 72.8	-
MID2 section Length Ø top Ø bottom Weight	 m m m t	-	 29.92 4.25 4.26 76.8	 20.16 4.26 4.28 77.4	 25.00 4.26 4.26 71.0**	 21.04 4.26 4.27 63.7	 18.15 4.27 4.28 75.2	-
MID1 section Length Ø top Ø bottom Ø T flange (bottom) Weight	 m m m m t	 26.95 4.02 4.02 - 55.8	 22.54 4.26 4.28 - 80.0	 12.13 4.28 4.29 - 72.0	 18.12 4.26 4.27 - 68.6	 18.12 4.27 4.27 - 74.1	 14.32 4.28 4.06 4.30 79.9	 23.01 4.29 4.29 - 45.5
Bottom section Length Ø T flange (top) Ø top Ø bottom Ø T flange Weight	 m m m m m t	 19.86 - 4.02 4.04 4.30 68.8	 15.38 - 4.28 4.05 4.30 80.0	 11.63 - 4.29 4.06 4.30 79.1	 12.72 - 4.27 4.05 4.30 69.5	 13.53 - 4.27 4.05 4.30 78.1	 10.94 4.30 4.06 4.07 4.30 78.5	-

*Not for N131/3900 // **Additional 5 t for the damper if used 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 %.

2.9 Anchor cages

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

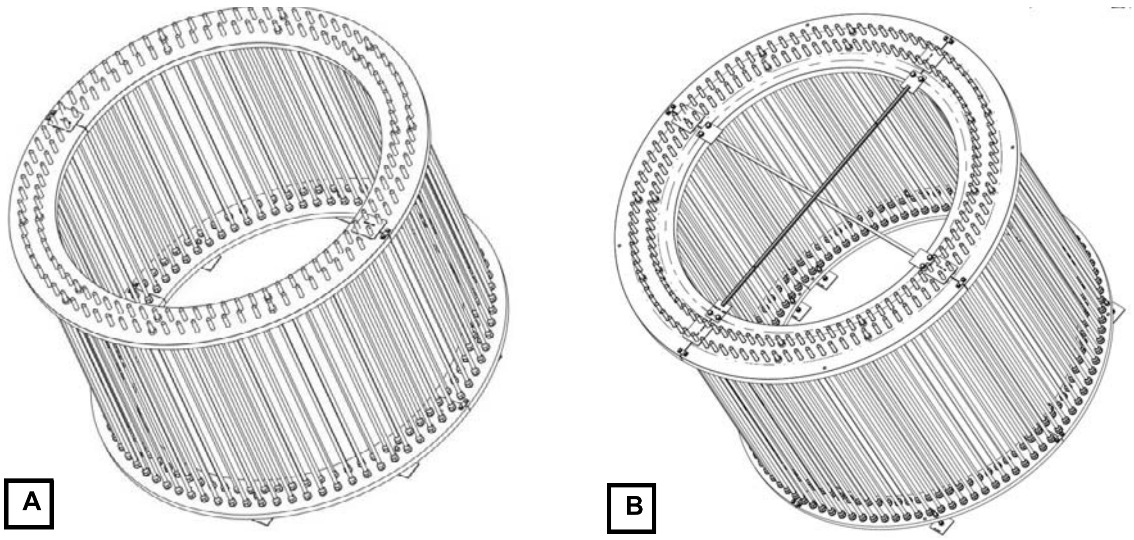


Fig.11 Examples of an anchor cage with 2 x 80 (A) and 4 x 50 (B) bolts

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

WT	Designation	Parts	Thickness	Maximum dimensions	Maximum weight
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 bolt	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 N117 or N131 TS120 (divided into four parts, similar to see fig.11B) (DIBt version)

WT	Designation	Parts	Thickness	Maximum dimensions	Maximum weight
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. 2.7 t
	Anchor bolt	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 3: 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	Maximum dimensions	Maximum weight
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. 2.3 t
	Anchor bolt	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 4: Anchor cage for N117 or N131 TS106 (divided into four parts, similar to see fig.11B)

WT	Designation	Parts	Thickness	Maximum dimensions	Maximum weight
N117 TS106 N131 TS106	Load-spreading plate	4	100 mm	Outside Ø 4690 mm	Approx. 6.6 t
	Anchor plate	4	60 mm	Outside Ø 4490 mm	Approx. 2.7 t
	Anchor bolt	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 5: Anchor cage for N131 TS112 (divided into four parts, similar to see fig.11B)

WT	Designation	Parts	Thickness	Maximum dimensions	Maximum weight
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 bolt	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 6: Anchor cage for N131 TS134 (divided into four parts, similar to see fig.11B) (IEC version)

WT	Designation	Parts	Thickness	Maximum dimensions	Maximum weight
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 bolt	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 N131 TS134 (divided into four parts, similar to see fig.11B) (DIBt version)

WT	Designation	Parts	Thickness	Maximum dimensions	Maximum weight
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 bolt	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

In general, the customer/client is responsible for planning the wind farm infrastructure based on the minimum requirements stipulated in this document. To prevent subsequent transport and erection problems, the planning must be coordinated with Nordex before starting the construction work. The infrastructure planning must contain at least the following information:

- 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 roads that 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

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 ambulance and rescue vehicles or fire-fighting vehicles is ensured.
It must also be taken into account that the heavy trucks 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

- Approx. 50 to 100 concrete transport trucks and construction vehicles, up to 220 vehicles for hybrid towers
- Approx. 15 to 40 heavy trucks for crane erection (depending on the hub height)

- Approx. 8 to 11 heavy trucks with turbine components (2 to 5 for tower sections, 3 for rotor blades, 3 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 exclusively for component transport)
- 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 3.4, 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) can be used so that steeper slopes can also be overcome under the provision of suitable surface conditions/bonded construction. The longer lengths of the entire tractor unit must be taken into account in road construction planning, especially with regard to 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.

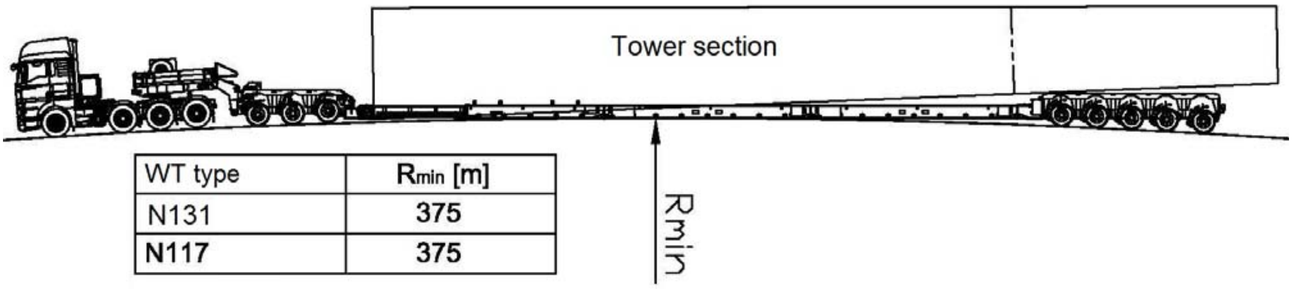
The lateral downhill slope must not be greater than 2 %.

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 for N117 and N131. 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.



WT type	R_{min} [m]
N131	375
N117	375

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 to 6.00 m (depending on transport method)
W	Clearance width	5.00 m

Due to bridges, the clearance height on public roads generally is approx. 4.5 m. 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.

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 transshipped 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.

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 signage.

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 8: 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 must be provided at the entrances to warn of electrical hazards and indicate the ground clearance. 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 8: 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 380 kV	5 m

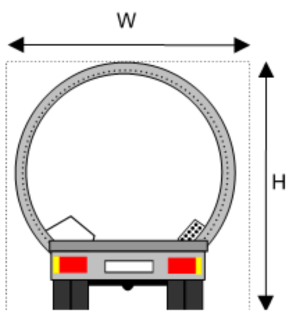


Fig.13 Clearance profile

3.3 Curves, opportunities for turning, and funnel lanes

3.3.1 Curves

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

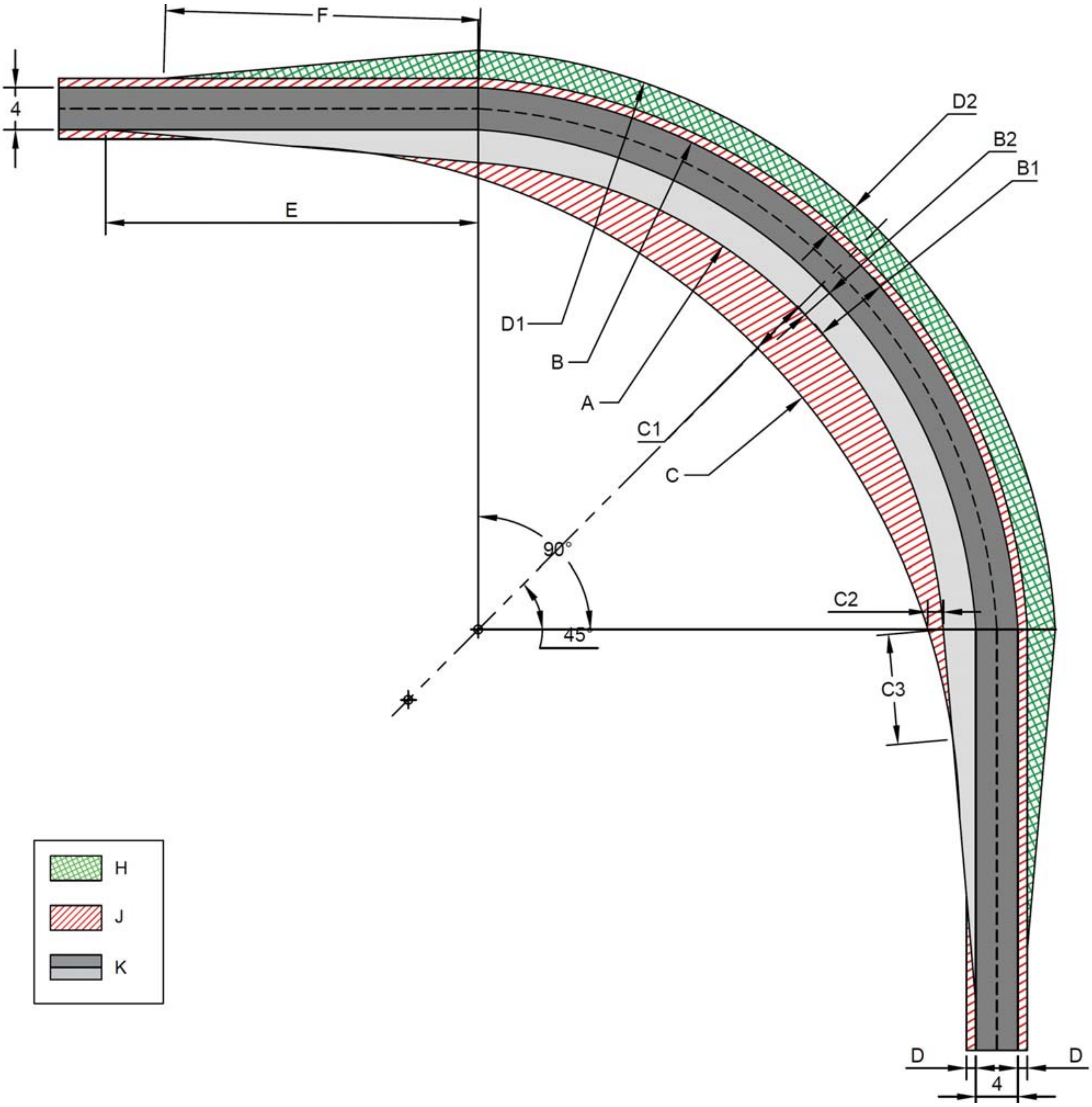


Fig.14 Minimum required structural support for 90° curve, general

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

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

K – Roadway/roadway extension = ground level

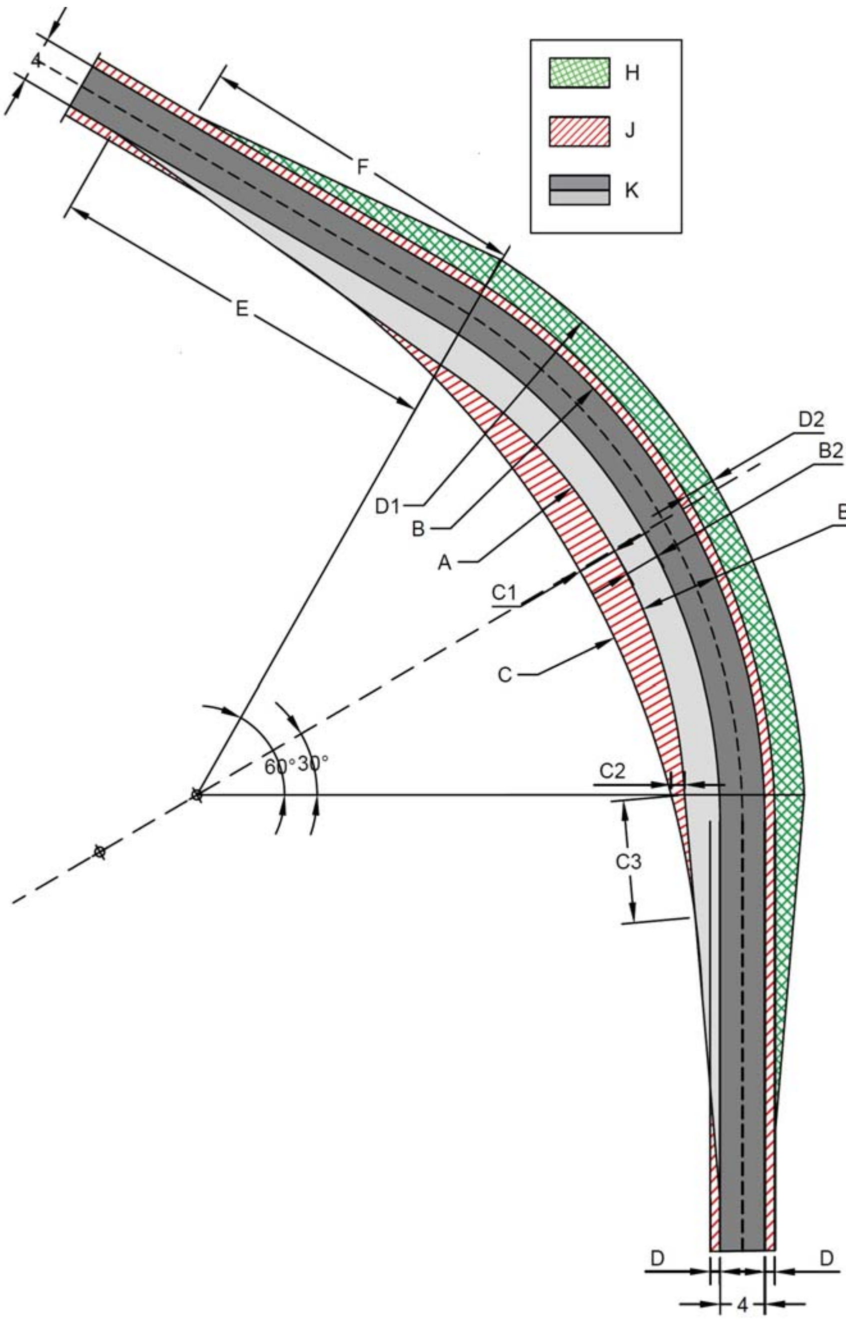


Fig.15 Minimum required structural support for 120° curve, general

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

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

K – Roadway/roadway extension = ground level

Table 9: Traversing and slewing areas for N117

	N117/90°	N117/120°	r 50 m ≤ R min ≤ r 150 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 10: 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 74 m	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 slewing areas by the vehicle and the rotor blade. The outer slewing area is determined by the length of the rotor blade projecting at the rear.

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

Due to the maximum steering angle of the rear axles of approx. 60°, curves that will reversed into must be constructed in a way that the slewing radii of the respective turbine types specified in chapter 3.4 can be traversed. 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 of 50 m around 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

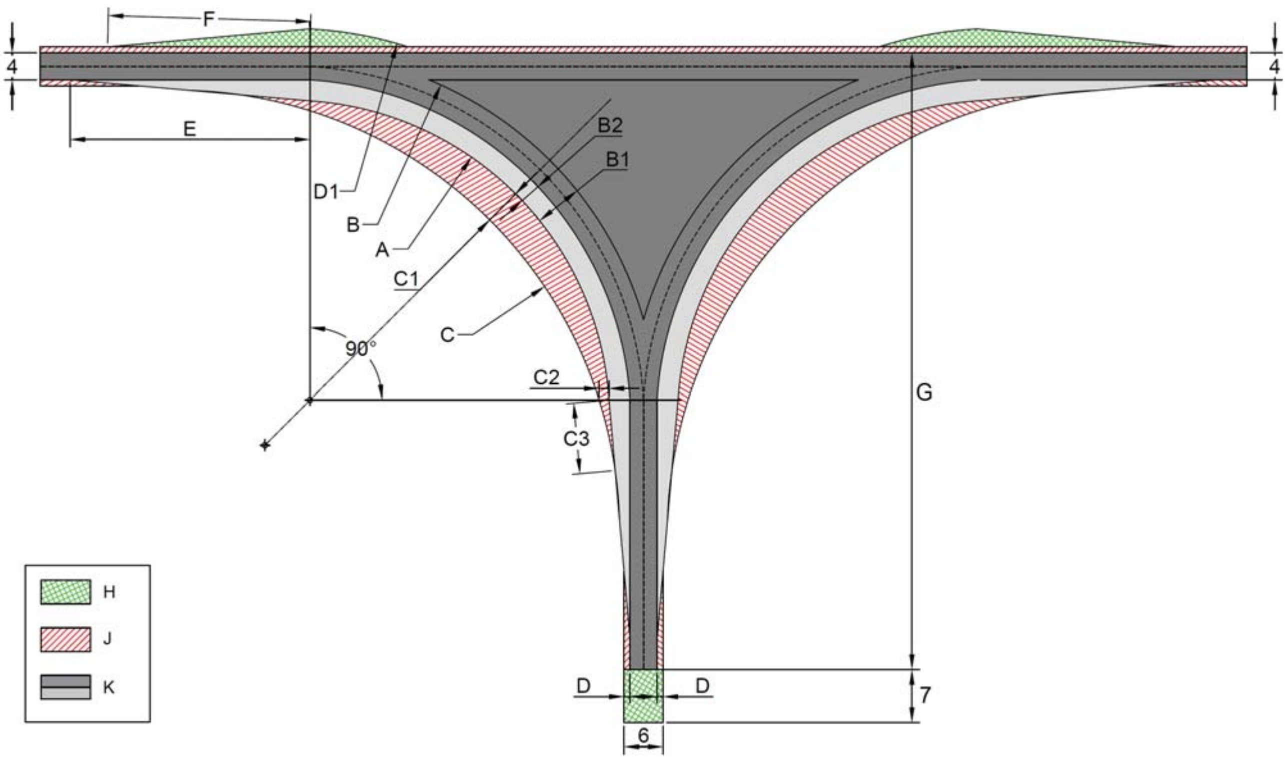


Fig.16 Structural support of funnel lanes; see previous chapter for explanation of variables

**G – Depth of funnel lane = transport length + 5 m (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. 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 customer from project-specific design and planning.

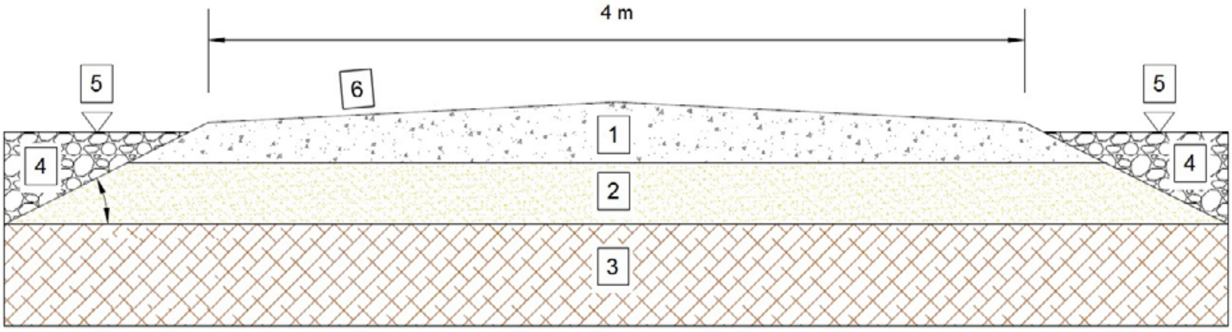


Fig.17 Schematic structure of access roads

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

- 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".
- On straight, level 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 connection, the side areas of the roadway must be stable and constructed with a minimum angle of banking 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)
- 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 trucks under any possible weather conditions during the entire construction period. Any damage to the road surfaces must be promptly repaired by the customer.
- 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 turnouts may be integrated into the auxiliary crane areas (crane hard standing area for the assembly of the crane jib), see fig.20. 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=70 m (N117), L=80 m (N131) must be provided every 500 m in addition to the existing main access road, allowing oncoming vehicles to give way. 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 serves as both arrival and departure road (dead end). These turnouts must be built as single-side, longitudinal turnouts with the dimensions 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 70 or 80 m each and run, e.g., along the left and right side of the access road. The extension of an access road behind or past the assembly area is recommended only for one vehicle length (approx. 70 or 80 m).

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

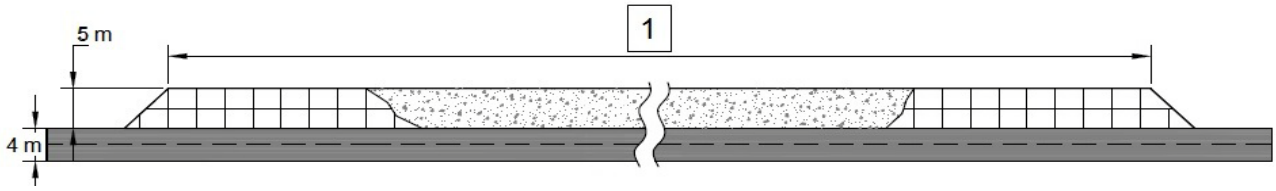


Fig.18 Normal turnouts (without integration into the auxiliary crane areas)

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

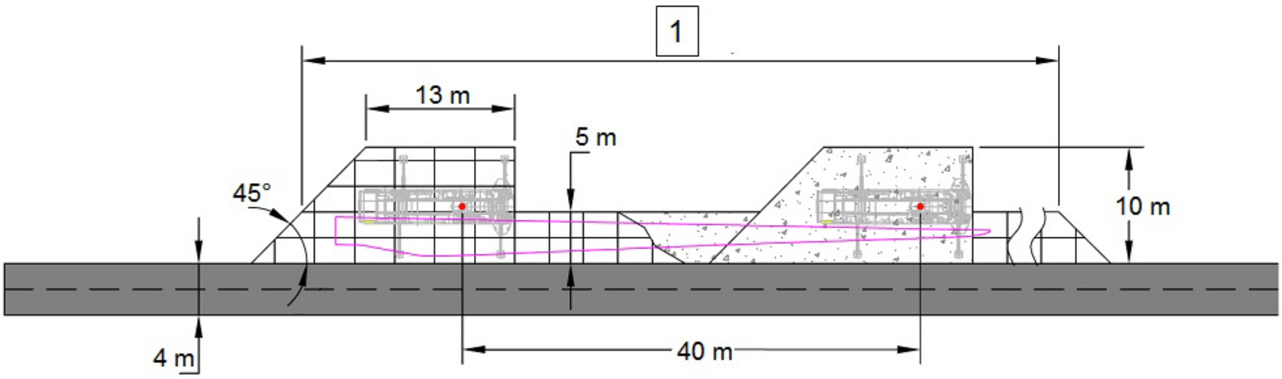


Fig.19 Turnouts with integration into the auxiliary crane areas

1 Length of the turnout:
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:

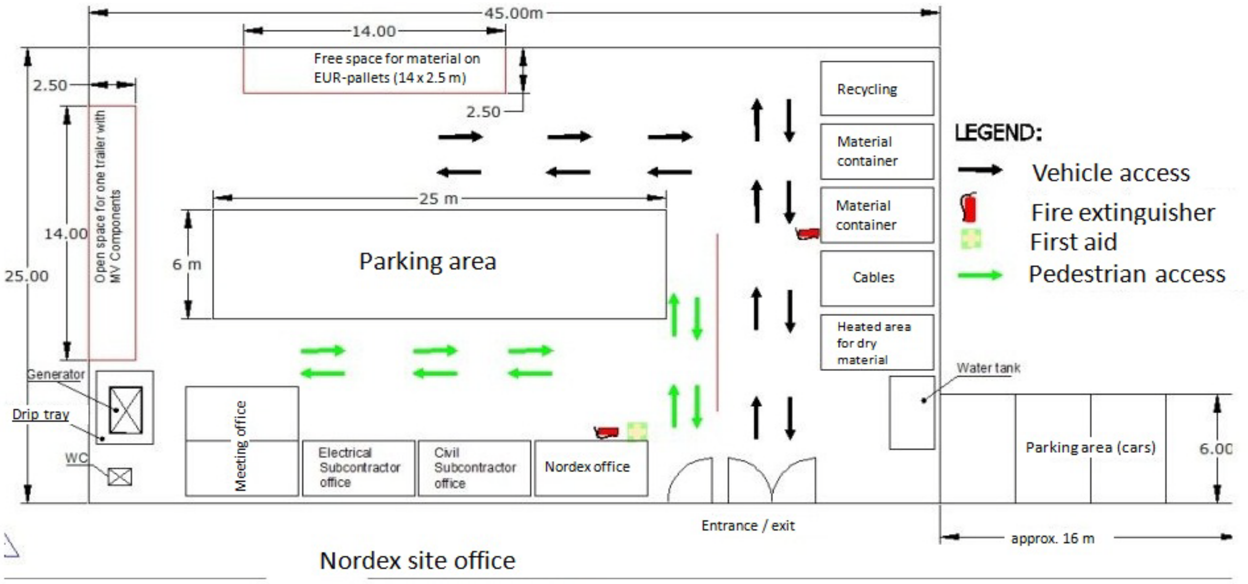


Fig.20 Nordex site office (example)

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 customer must provide an area of approx. 1200 m² to accommodate the following equipment and facilities:

- Nordex office – 20 ft container
- Office for responsible company – 20 ft container
- Office for meetings – 20 ft container
- Generator with drip tray
- Recycling
- Empty area for material on EUR-pallets (14 m x 2.5 m)
- Restroom
- Empty area for material (fenced: 14 m x 2.5 m)

- 4x 20 ft material container (2x for material / 1x for cables / 1x for storing material in dry and heatable places)
- 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. The inspection results must be submitted to Nordex no later than 4 weeks before delivery starts:

Quality inspections	**Minimum number/ comments**
Degree of compaction (D_{pr}) 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 areas** in layers (bed, base layer, 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.

3.4 Public roads

In general, the customer is responsible for providing the access roads from the destination port or the freeway exit to the construction site. The customer is also in charge of planning, obtaining permission and executing all necessary constructive measures.

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

Main crane radius 15 - 30 m (depending on crane type)

Auxiliary crane radius 6 - 12 m (depending on crane type)

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

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

Hub height	**84 m**	**106 m**	**112 m**	**114 m**	**120 m**	**134 m**
WT type	N131	N131	N131	N131	N131	N131
Main crane - Maximum hook load of an individual module (single blade assembly)	>69 t	>80 t	>79 t	71/76 t*	>78 t	>80 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	 >92 t >67 t
Auxiliary crane Required hook load	>40 t	>40 t	>40 t	>40 t	>40 t	>40 t

* Maximum weight at N131/3600 or 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. The soil pressure depends on the maximum weight of the components and the size of the crane used (mobile crane, crawler crane) and must be at least 250 kN/m².

The entire crane hard standing area must be level, must not have any slope and must be planned such that the height difference between hard standing area and foundation top edge is not greater than 1.10 m (hybrid tower up to 141 m hub height: 1.80 m). If this value is exceeded, a larger and more expensive crane may be required.

The crane hard standing area, erection area 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, the space for the star assembly and the space for assembly of the crane jib must be considered for crane operation.

Excavated material must be stored only outside the illustrated assembly areas and 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 be placed only on the crane hard standing area or, using crane mats/wooden supports, on suitable stable ground.

For the assembly of the crane jib for 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 graveled 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.

Examples

- Example 1 shows a crane hard standing area for wind turbines up to 100 m tower height with just-in-time delivery. Higher transport costs are generally to be expected for this variant. The detailed layout for the specific site must be planned after the site has been inspected.

- Example 1a shows a crane hard standing area for wind turbines up to 100 m tower height with storage areas for advance delivery of turbine components including tower sections and rotor blades. The detailed layout for the specific site must be planned after the site has been inspected.
- Example 2 shows a crane hard standing area for wind turbines up to 134 m tower height (tubular steel tower) with just-in-time delivery. Higher transport costs are generally to be expected for this variant. The detailed layout for the specific site must be planned after the site has been inspected.
- Example 2a shows a crane hard standing area for wind turbines up to 134 m tower height (tubular steel tower) with storage areas for advance delivery of turbine components including tower sections and rotor blades. The detailed layout for the specific site must be planned after the site has been inspected.
- Example 3 shows a crane hard standing area for wind turbines with hybrid tower and advance delivery of the large components. Higher transport costs are generally to be expected for assembly with just-time delivery (without additional storage areas). 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) 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 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.

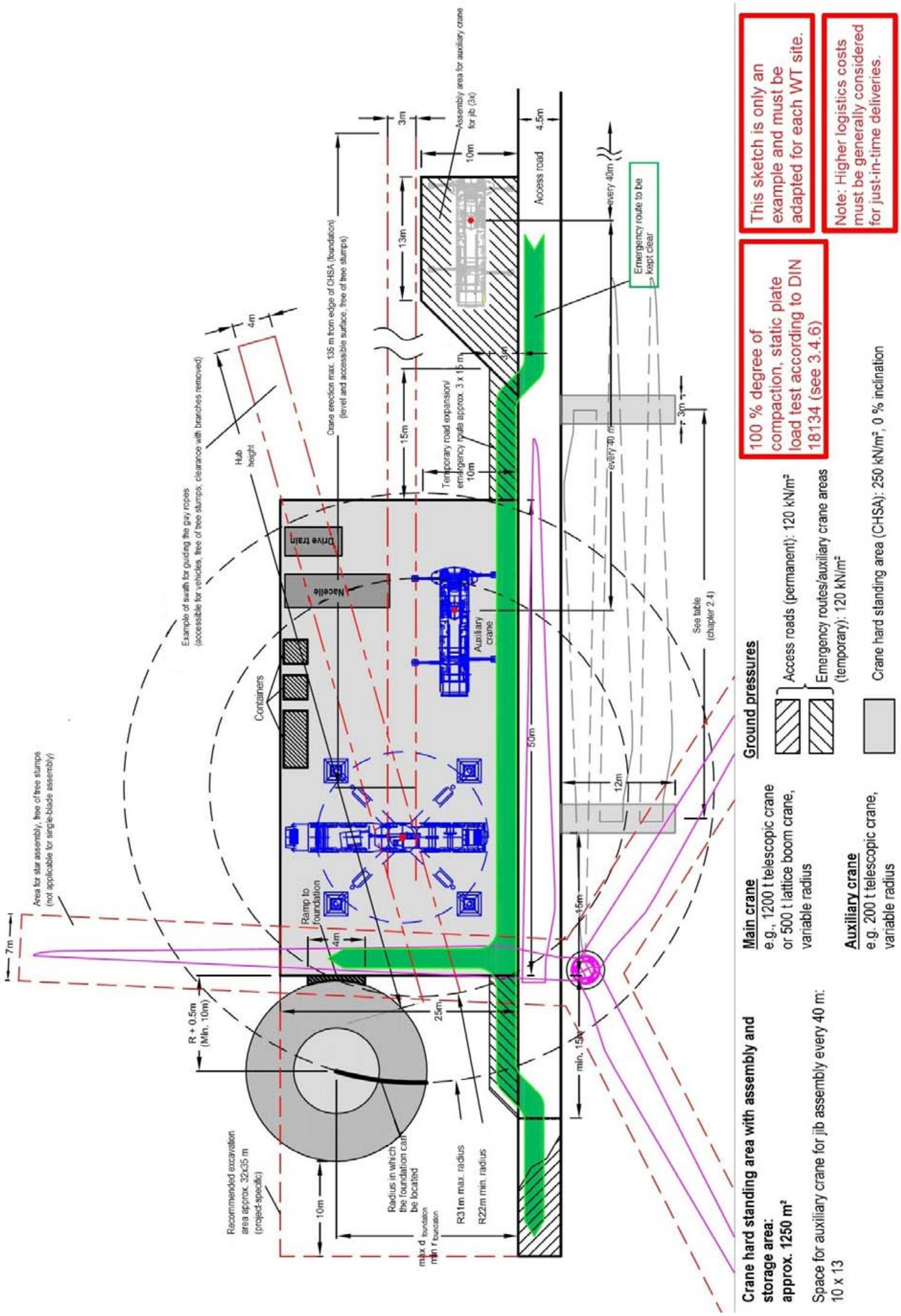


Fig.21 Example 1 – Crane hard standing area for WTs up to 100 m hub height with just-in-time delivery

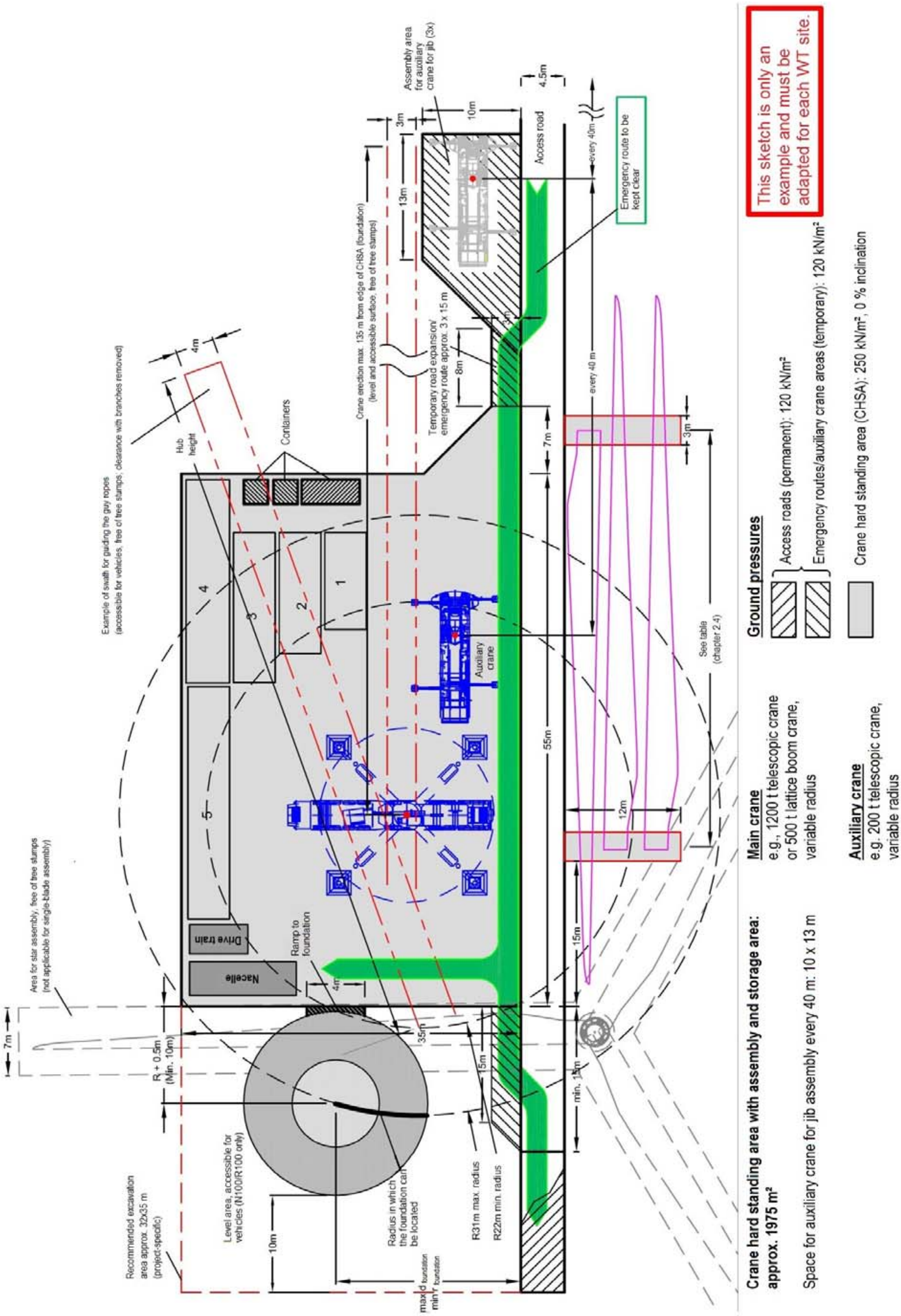


Fig.22 Example 1a – Crane hard standing area for WTs up to 100 m hub height with advance delivery

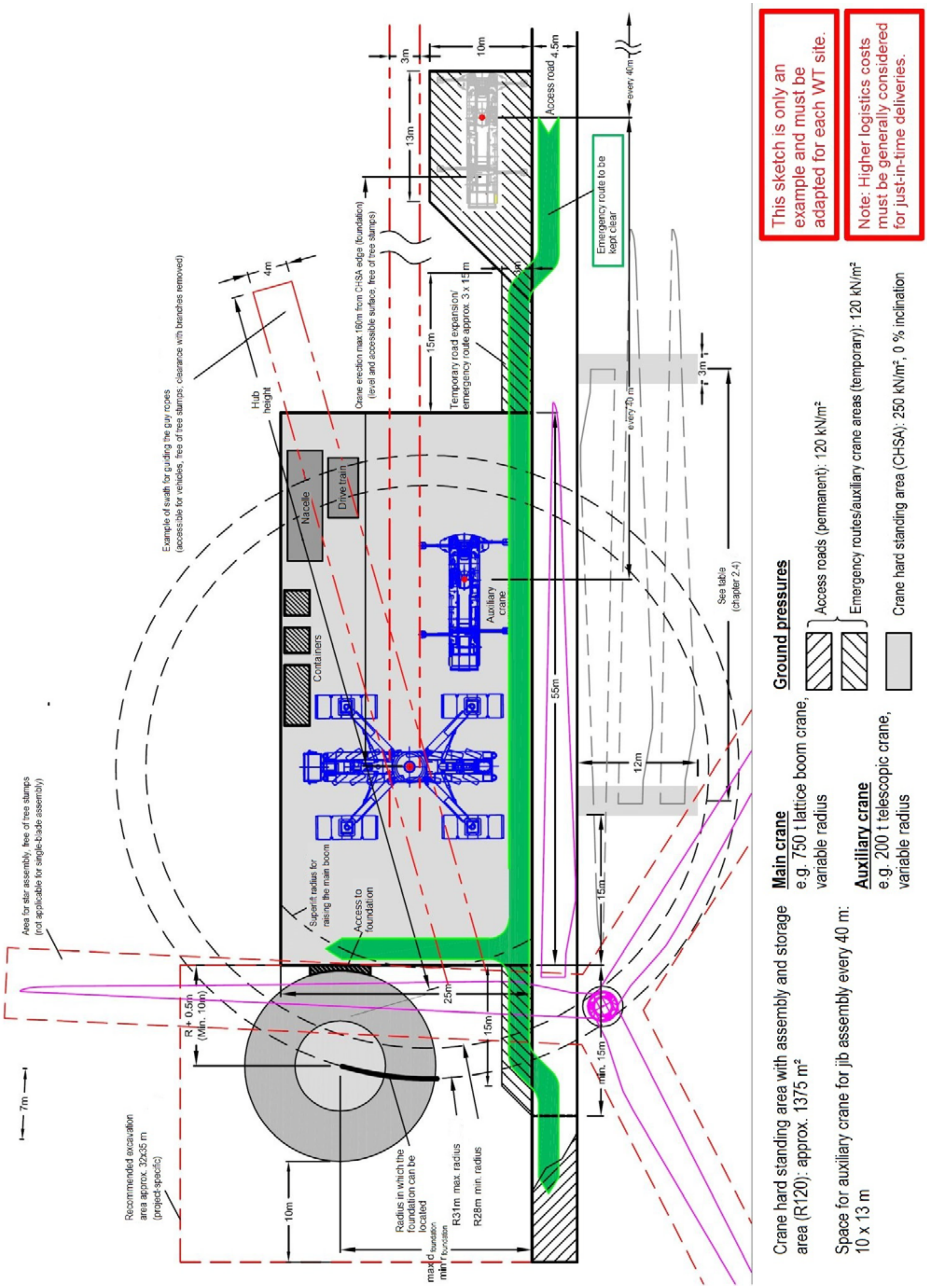


Fig.23 Example 2 – Crane hard standing area for WTs up to 134 m hub height (tubular steel tower) with just-in-time delivery

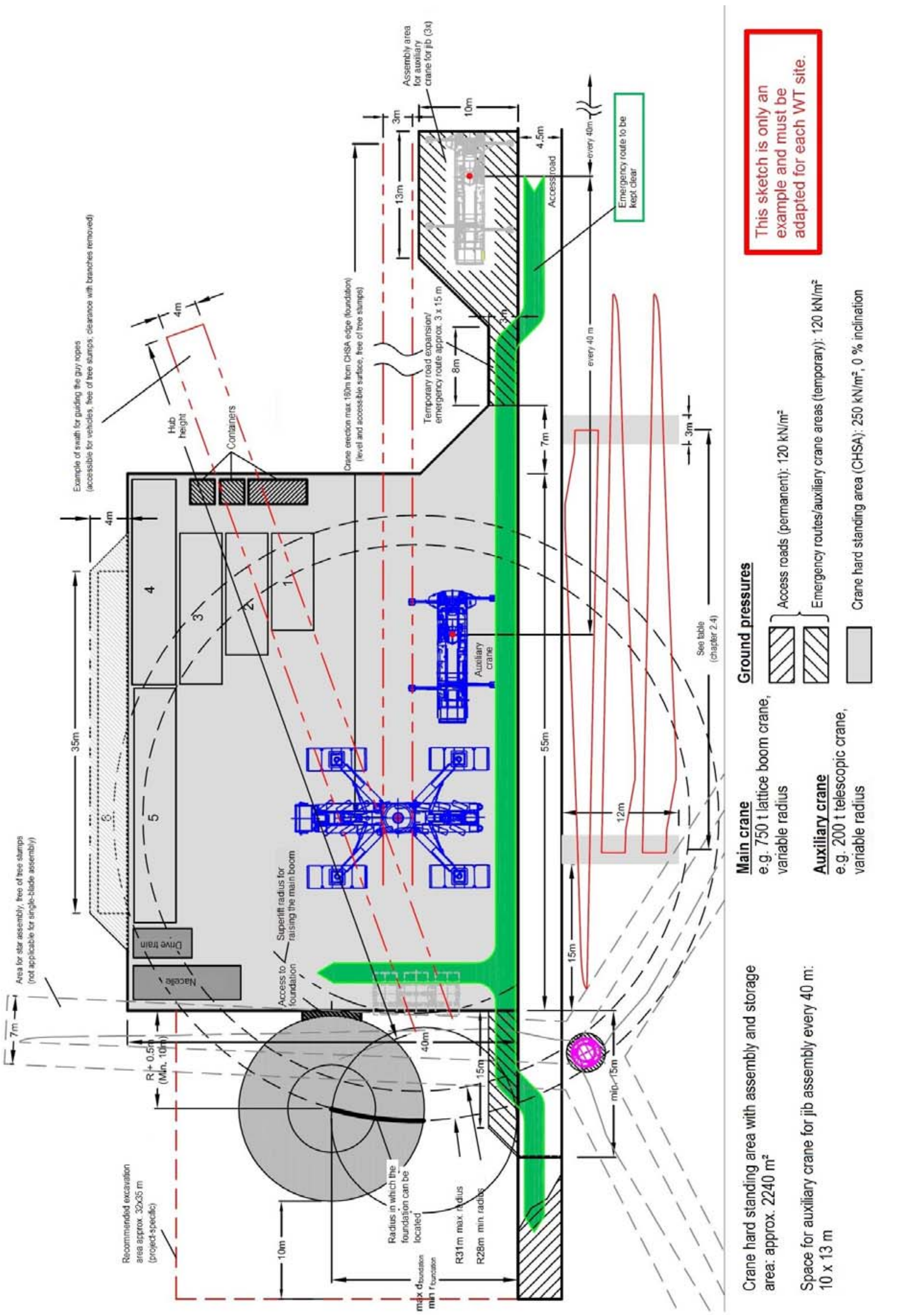


Fig.24 Example 2a – Crane hard standing area for WTs up to 134 m hub height (tubular steel tower) with advance delivery

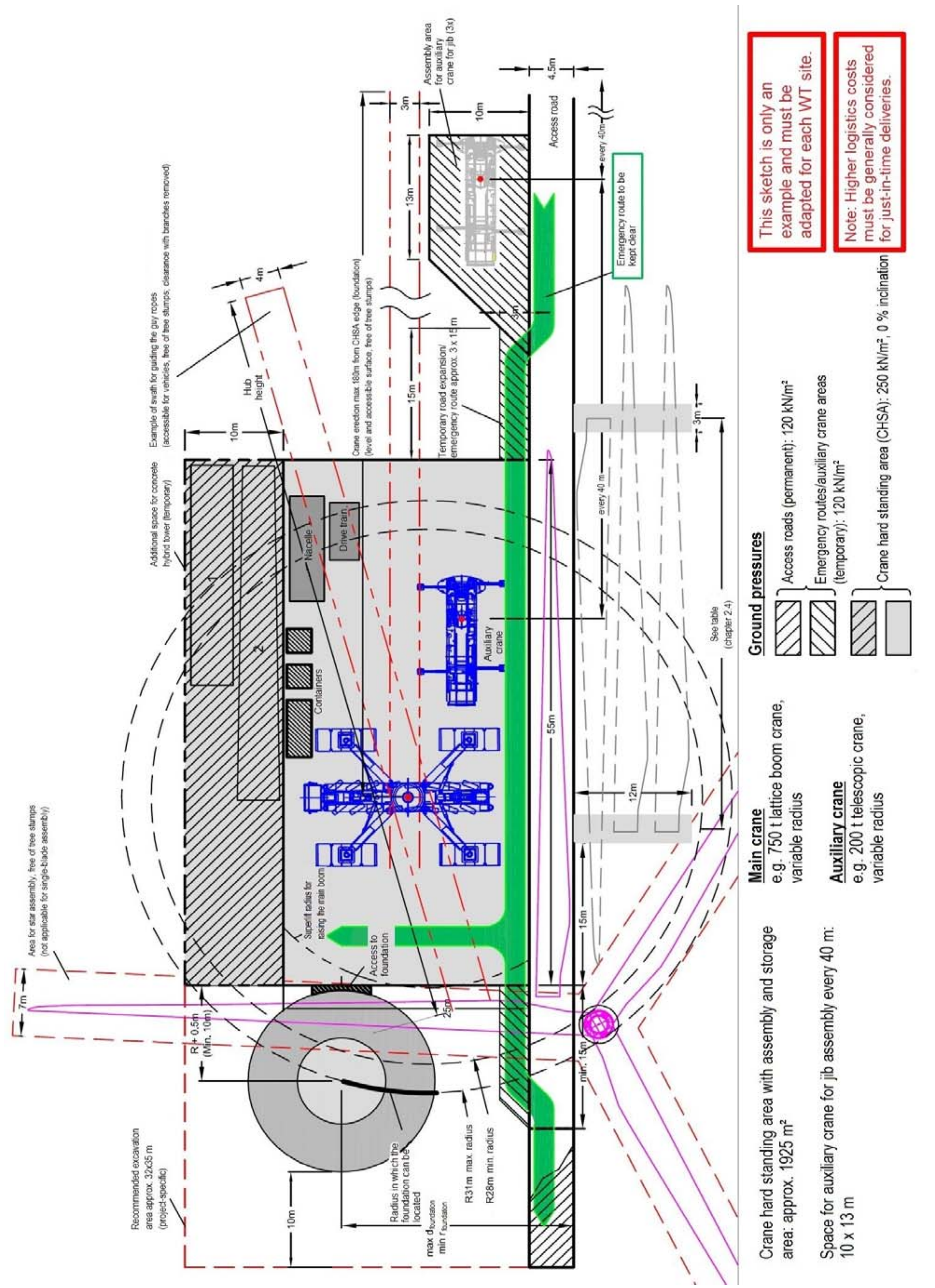


Fig.25 *Example 3 – Crane hard standing area for hybrid tower with advance delivery and star assembly*

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

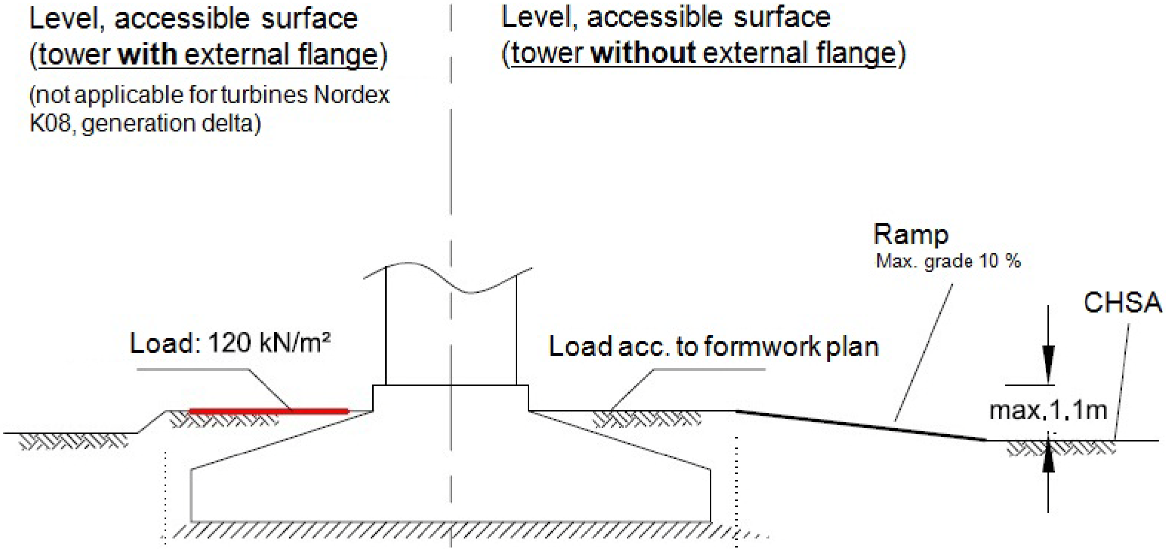


Fig.26 Area around the tower – sectional view

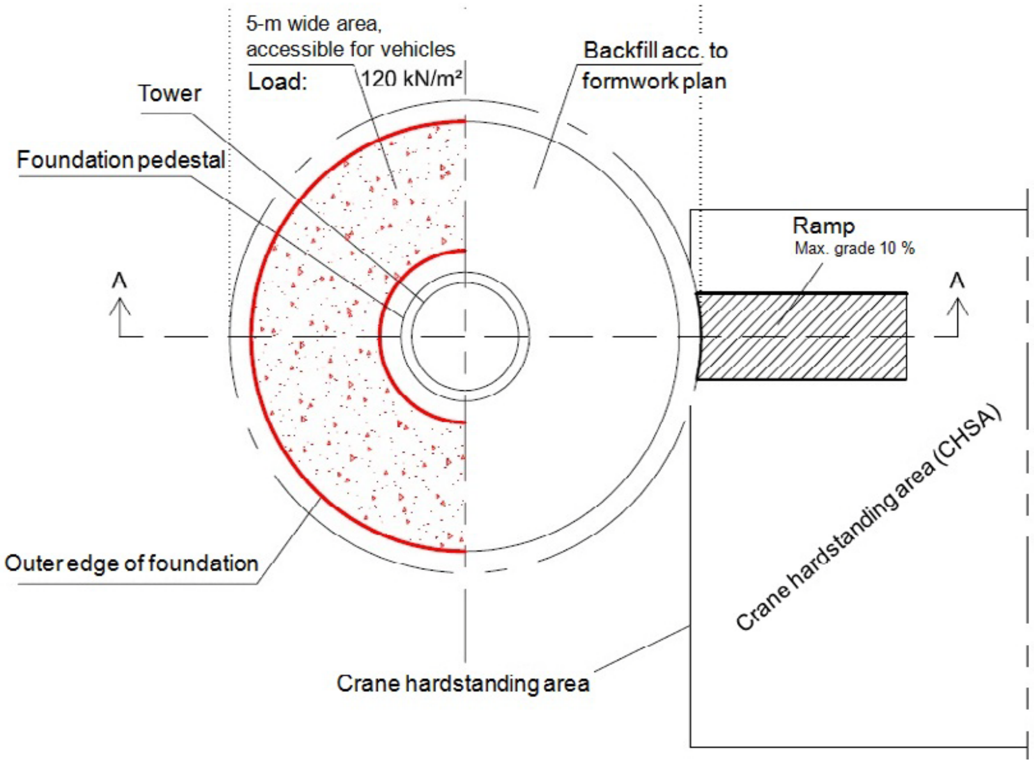


Fig.27 Area around the tower – top view

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