Appendix E

Heavy Construction Equipment Specifications

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General Requirements, Site Infrastructure Layout

BONUS 2.3MW Wind Turbine

- **with 40 m blades / rotor diameter 82,4 m**
- **with 45 m blades / rotor diameter 92,4 m**

Report name **Siemens Report SC-2300-01, rev 4 / 10.05.05**

Rev.	Date	Change	Responsible	Checked
2	25.01.2005	Layout and structure changed	AO	BAN
3	04.02.2005	Grammar changes	AO	
4	10.05.2005	Content updated	MLO	BAN

Table of Content

1. Introduction

This document contains information about the requirements to the site construction area, public roads as well as site roads. The site structure for the working-, compound-, storage areas and crane hard standings are described. The requirements are set in order to meet the methods and logistic that Siemens knows by experience has proved to work for the 2.3MW turbine transport and installation.

Non conformances to the specifications can cause major problems for transport, mounting and handling the turbine components. Therefore, all changes should be agreed and accepted by Siemens Wind Power Project Department. Non compliance and additional demands must be listed in the associated document 'Project specific information'. This document is intended to be updated as the agreements with crane and transport suppliers are made.

Overall requirements and notes:

- Generally, the requirements to both public access roads and site roads are such that it shall be possible to drive heavy cranes and oversize trucks safely to the site. This must be during practically all weather conditions.
- All known road access restrictions must be mentioned and listed.
- Specifications of trucks and cranes may vary according to the commercial conditions and the availability of the equipment at the time of installation. However the contract with cranes and transport will be based upon the specified requirements in this document, but loads and the specified restriction may change according to transport and crane contract. Changes will be listed in 'Project specific information' as agreed.
- Prior to the construction of the site roads and hard standings, the contractor should present his designs to Siemens Wind Power's Project Department, for review.
- Siemens requires a survey of the site and site layout after the construction of roads and construction area prior to commencing deliveries of turbines.
- It is outside Siemens Wind Power responsibility to maintain the roads (pot holes, landslides, etc.) during the turbine installation period.
- All non confirmative to the design criteria and restrictions otherwise must be listed in 'Project specific information'
- Safety is the ruling factor in all situations; all deliveries shall be managed by the Siemens Site Manager and coordinated with the Customer's Site Manager.

2. Road requirements for turbine parts and crane equipment

2.1. Loads

The total weight of the heaviest transportation vehicle (nacelle delivery) is approximately 145T with an axle load of approximately 14T. If the requirements on public roads are stricter these guidelines are to be followed.

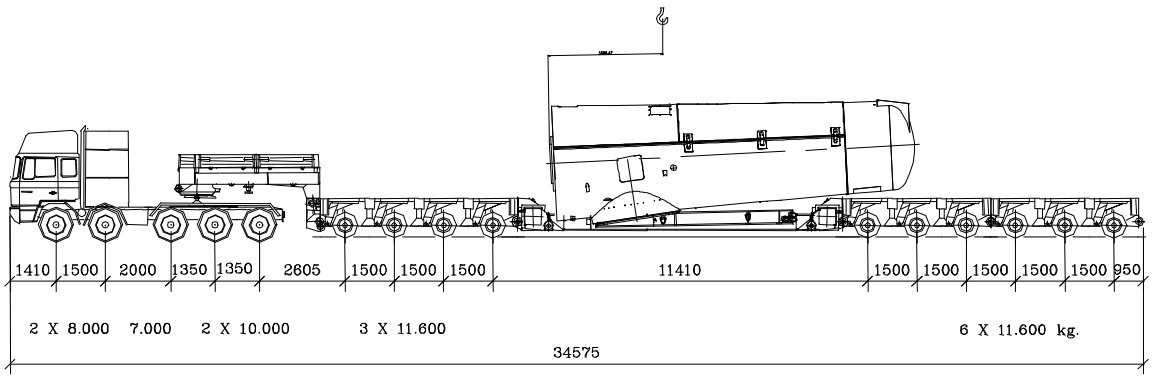
Indicative layouts of delivery trucks are inserted on the following pages.

Depending on the type of crane equipment chosen for the specific project, the axle loads of the

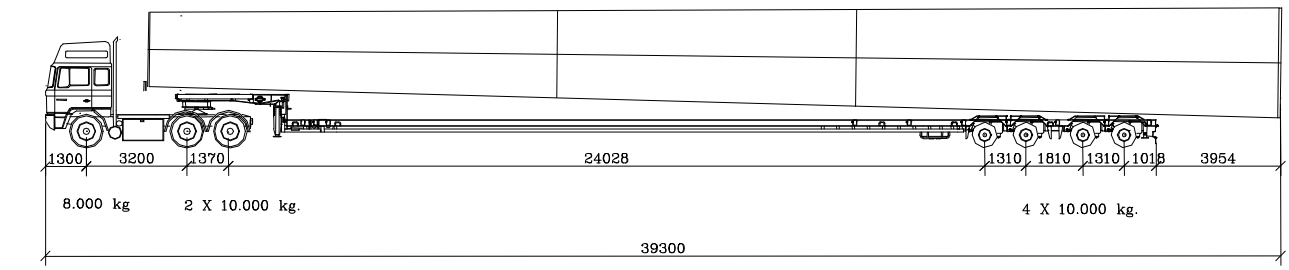
crane equipment may vary from 14T up to 30T, depending on weather the cranes are fully disassembled or fully assembled while operating on the site. If the site roads are constructed as floating roads, the cranes will be disassembled to reduce the axle load. If the site roads are constructed as floating roads it should be noted in list of 'Project specific information'.

The speed of transportation on site roads is normally 5-10km/h.

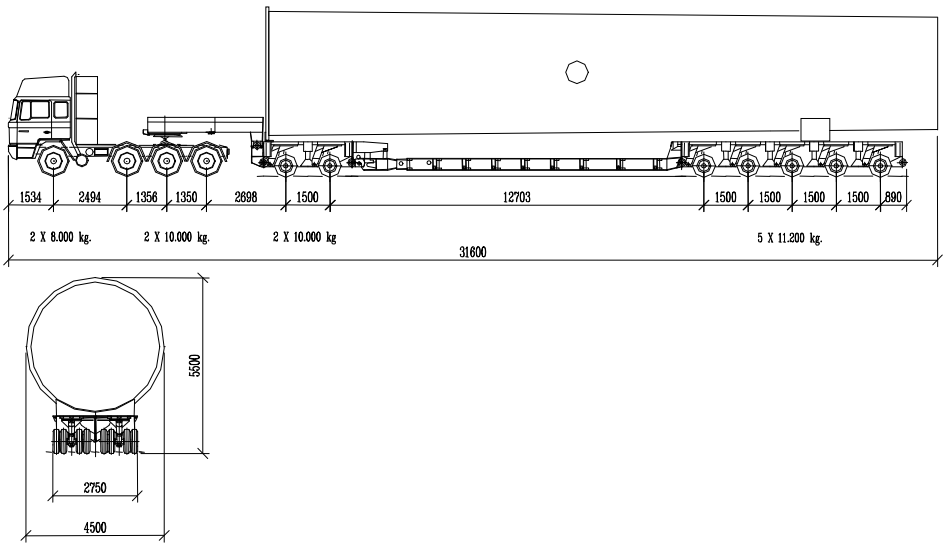
Note that the specified axle loads are only valid on straight, level roads and do not take into account uneven roadway, road rise or bends. All axle loads are exclusive safety factors. It is the designer's responsibility to incorporate adequate safety into the design of the roads according to national standards.



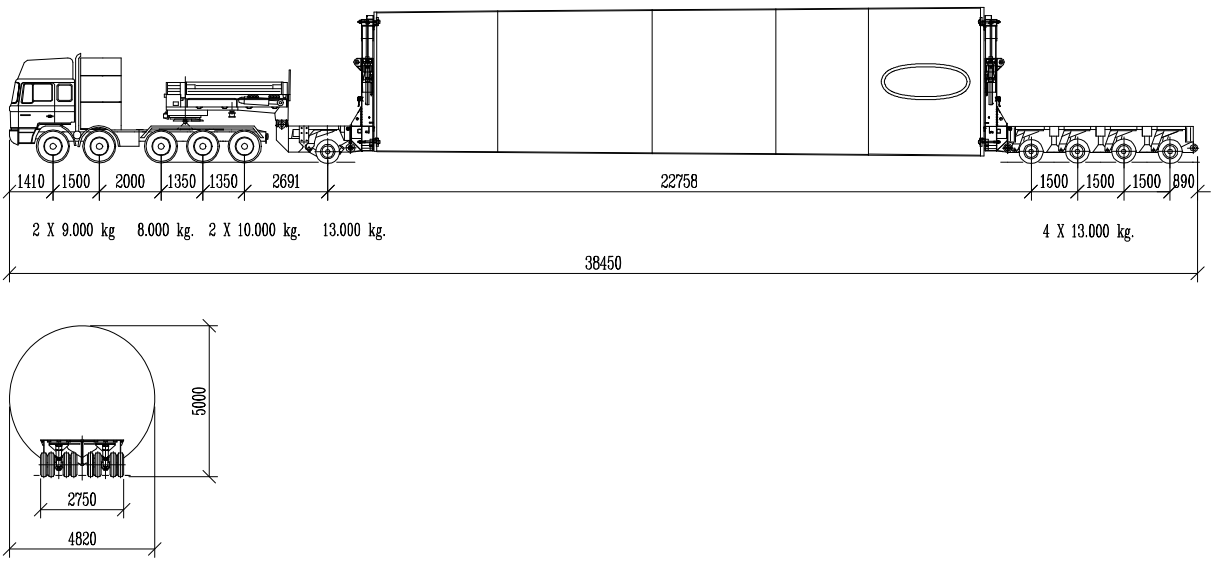
Nacelle transport - indicative



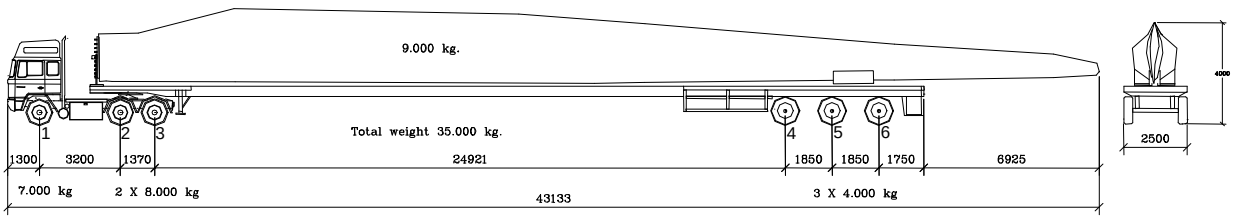
Tower top transport - indicative



Tower base transport, alt. 1- indicative



Tower base transport, alt. 2 - indicative



Single blade transport (40 m blade) - indicative

2.2. Gradients

The maximum allowable gradient on roads is **1:9 (11%)** which requires a well compacted road with a good road grip. This is assuming a reasonable straight road without narrow bends. Bends with a radius less than **45m** shall be with negligible gradient.

Steeper gradients require special arrangements (exc. paved surface) and need to be reviewed together with the actual forwarder. Unless otherwise agreed and confirmed in writing, Siemens Wind Power A/S has not allowed for any special equipment in this respect.

2.3. Bends and crosses

Bends and cross roads shall be constructed according to following requirements to ensure that the transport can operate safely on the roads. In cases where the transport has to reverse on the site roads, extra width of the roads is required. Normally 0.5 m is accepted but it depends on the actual conditions, example inclination near edge of the road, conditions and bearing capacity of the surrounding land.

The distance between bends must be more than 45m.

The following figures show types of bends and T-junction. The hatched areas on the figures are areas that have to be cleared for obstacles to allow overhang.

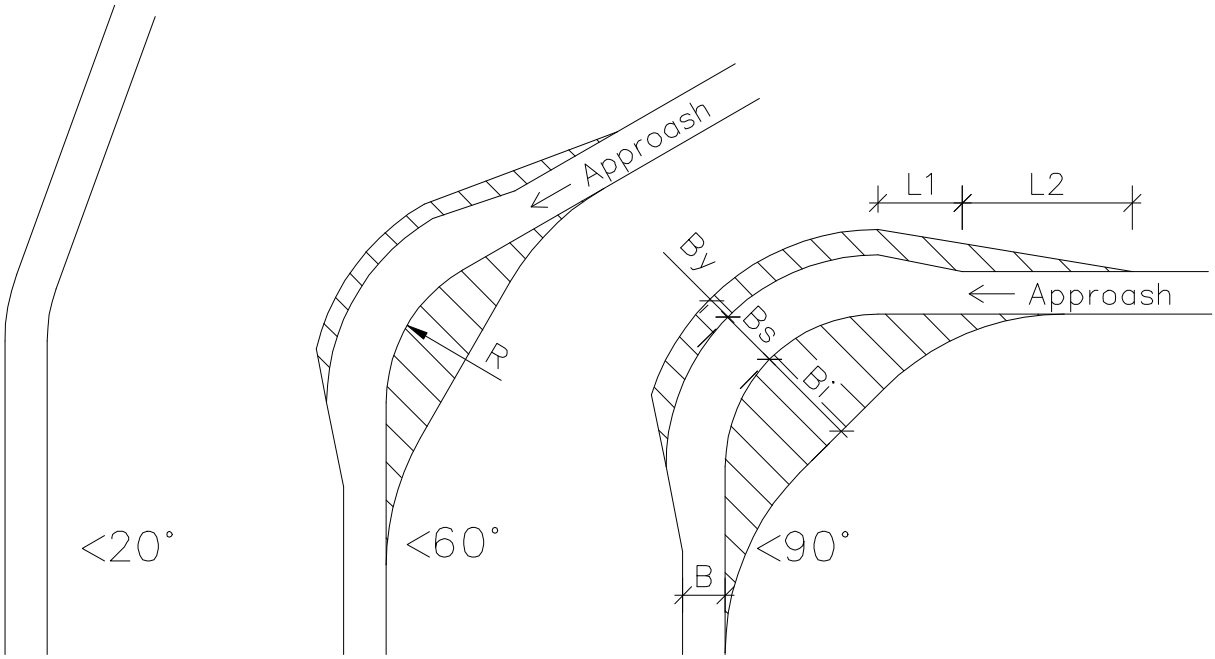


Figure 1 Bends more than 20 degrees or an internal radius less than 58m, shall have a minimum running width, Bs, of 7m. Minimum allowable inner radius R=18m (40 m blade) R=22,6m (45 m blade).

Requirements for Bends with Radius R= 18m / 22,6m Width of road : Bs = 7m, L1, L2: approximately 10m -15m			
Max. bend	< 20°	<60°	<90°
Cleared areas B_y	0	2/3	3/4
B_i	0	8/11	12/15

IMPORTANT: Bends sharper than 90 degrees must be custom built and discussed in detail with reference to the actual transport equipment. Road rise is not accepted in bends with radius less than 40m.

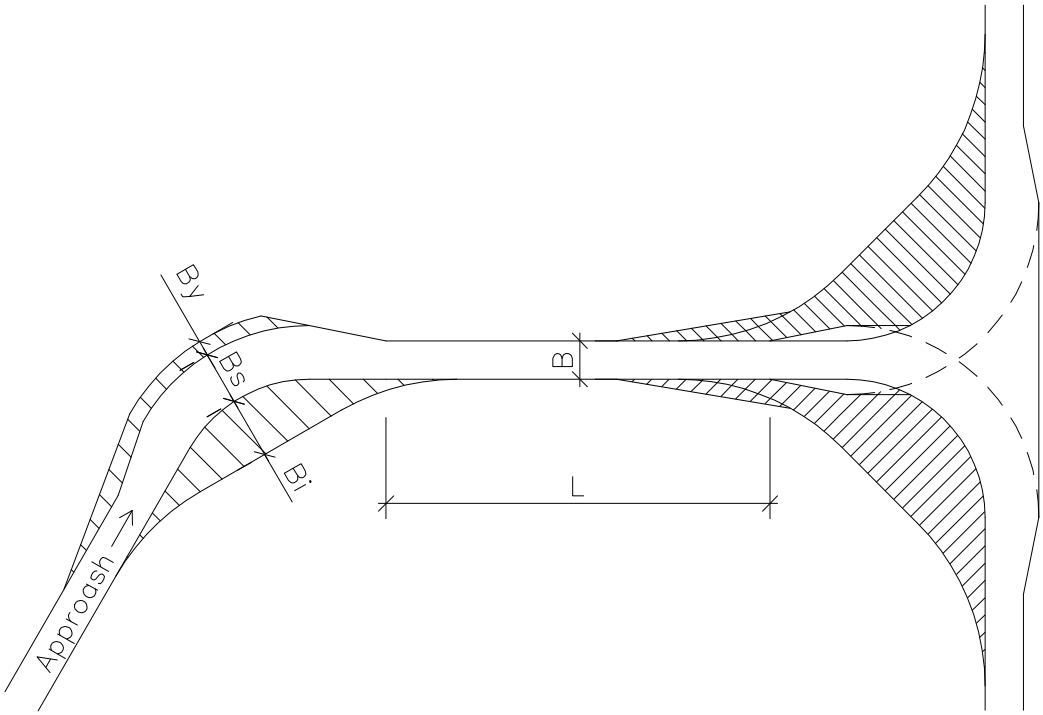


Figure 2 Example of road bend followed by T-junction (L= app. 50m).

2.4. Sectional view

All trucks are normal road-going trucks which require that the site roads have a reasonable running surface to avoid damages to tires and other equipment.

For transport of the turbine parts the effective running width of the road must be minimum 5m exclusive shoulders on straight sections of road.

If a mobile crane / conventional crane is chosen for the specific project it will be fully disassembled when moving from one site location to another. It will require an effective running width of the road of minimum 5m exclusive shoulders on straight sections of road.

If a crawler crane is chosen for the specific project it will be able move from one site location to another fully assembled. It will require an effective running width of the road of minimum 10m exclusive shoulders on straight sections of road.

The maximum allowable cross-fall roadside to roadside over the running width is 1:50 (2%). If the road is constructed using a "roof" profile an increased cross-fall can be accepted 1:25 (4%) as long as a vehicle (width 2,5 - 3m) will not incline more than 1:50 (2%) while driving in the centre of the road.

The height clearance at public roads should be 5,7m. At site roads the height clearance must be 8m, with consideration to the height of the nacelle including wind vane.

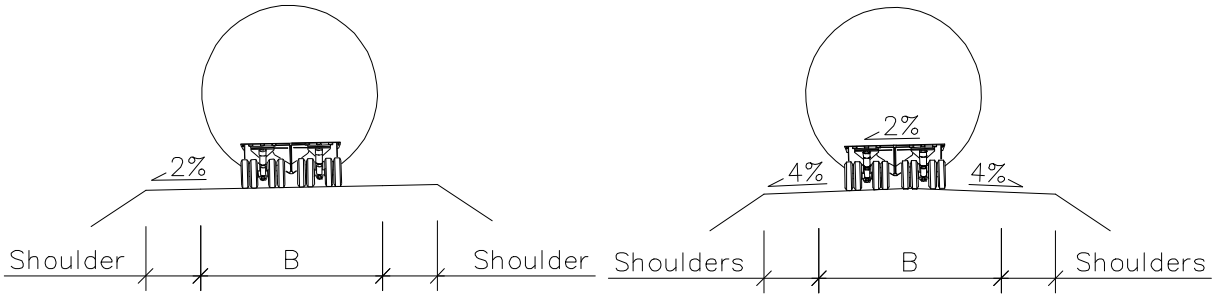


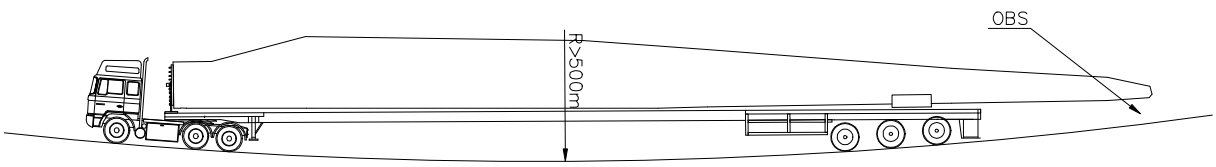
Figure 3 The effective running width, B must be minimum 5m exclusive shoulders on straight sections of road.

It is important to construct the road in a way that the total effective running width, B, do have the bearing capacity as specified in sections '2.1 Loads'. This means that verges, drainage, shoulders etc., have to be designed to ensure that the effective running width of 5m is kept. The design has to include all stability issues during all conditions of use. For special critical bends, for example bends on hillsides, verges must be marked with cones or similar.

Especially if the site roads are designed as floating roads, extra safety should be included due to the fatal consequences in case of collapse. Information about any floating roads must be specified and listed in 'Project specific information'.

2.5. Longitudinal view

The longitudinal radius on roads, both convex and concave direction (hills and hollow/dip), should not be less than 500m to ensure that the vehicles can pass without touching the road surface.



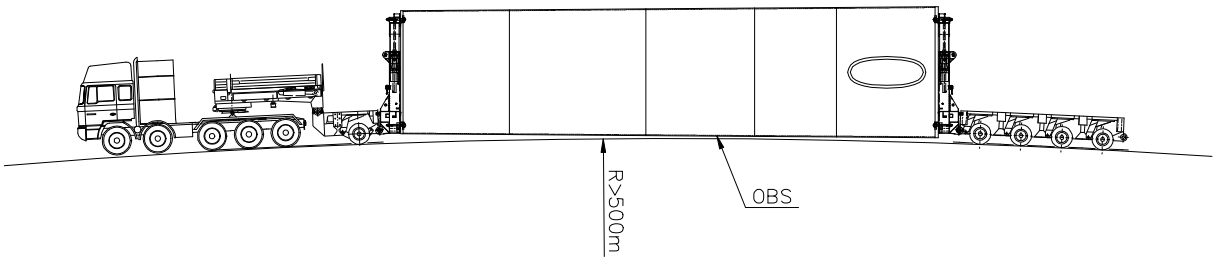


Figure 4 The longitudinal radius, R on the road should not be less than approximately 500m.

3. Passing- and turning areas on site for turbine parts and crane equipment

Passing areas for oversize vehicles and crane equipment should be made at approximately 500m intervals on the site layout. Crane hard standings can be used if fulfilling the requirements for passing.

Where dead-end roads are constructed turning areas are required. If the turning area is not constructed as described below, the length of the road after the crane hard standing should be at least 15m.

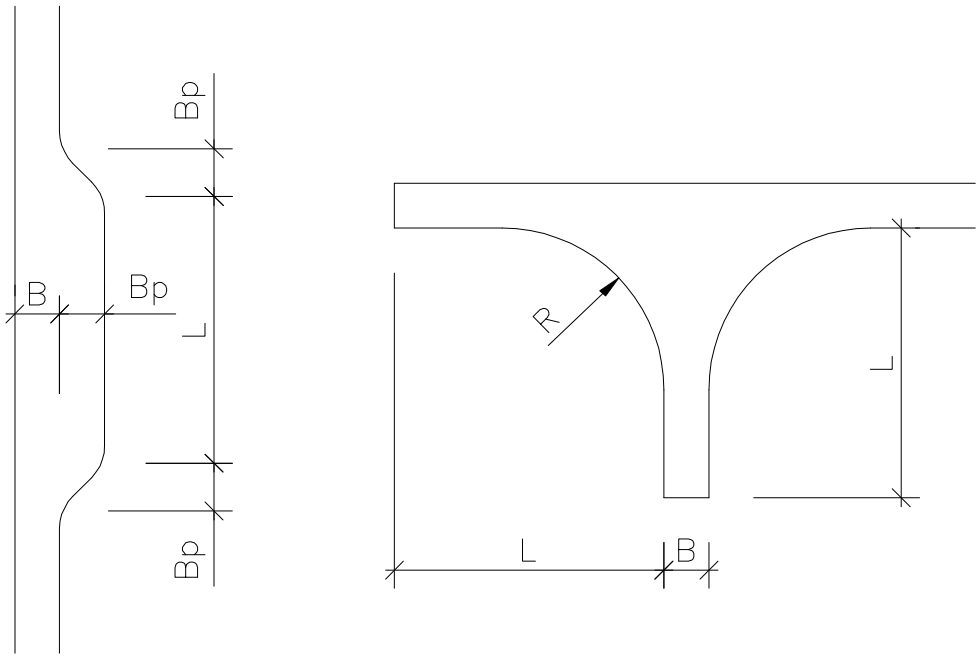


Figure 5 Passing - and turning areas.

Radius turning area	*R*	*Min 18m / 22,6m*
Length of passings and turnings	*L*	*40m / 45m*
Width of road	*B*	*5m*
Width of passing	*Bp*	*5m*

4. Turbine Construction Area

Depending of the site conditions of the specific project and taking the commercial conditions as well as the availability of the equipment at the time of installation into consideration, minimum 2 types of main cranes can be chosen.

- Crawler crane: for this type of turbine depending on the hub height, i.e. a CC2500 could be the choice of main crane, allowing the crane to move from one site location to another fully assembled.
- Mobile crane / conventional crane: for this type of turbine depending on the hub height, i.e. a LG1550 could be the choice of main crane. It will be fully disassembled when moving from one site location to another

The following drawings, showing Mobile cranes / conventional cranes, are examples of 2 types of typical main operations at the construction area:

a) assembling the main crane
b) and assembling the rotor and mounting the tower

The logistic and deliveries depends on the actual site conditions, type of crane, transport facilities, etc. and are changed and adjusted according to the actual project as the project progresses. All details on each site must be clearly agreed and planned at an early stage of the project. It is important to note that the crane hard standing is normally used as a working area with tools, containers etc.

In the figures below it is assumed that the direction of the transport is from the right assuming the bottom end of the tower is near the driver's cap.

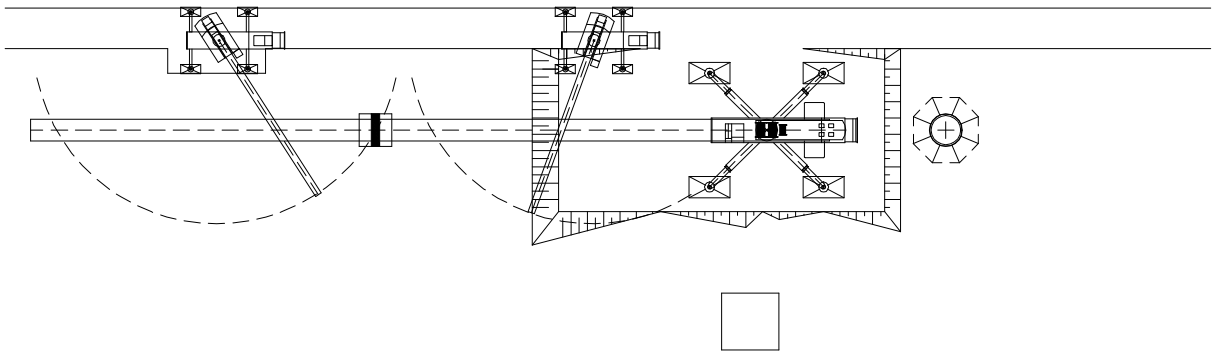


Figure 6 Example of crane hard standing – assembling the crane.

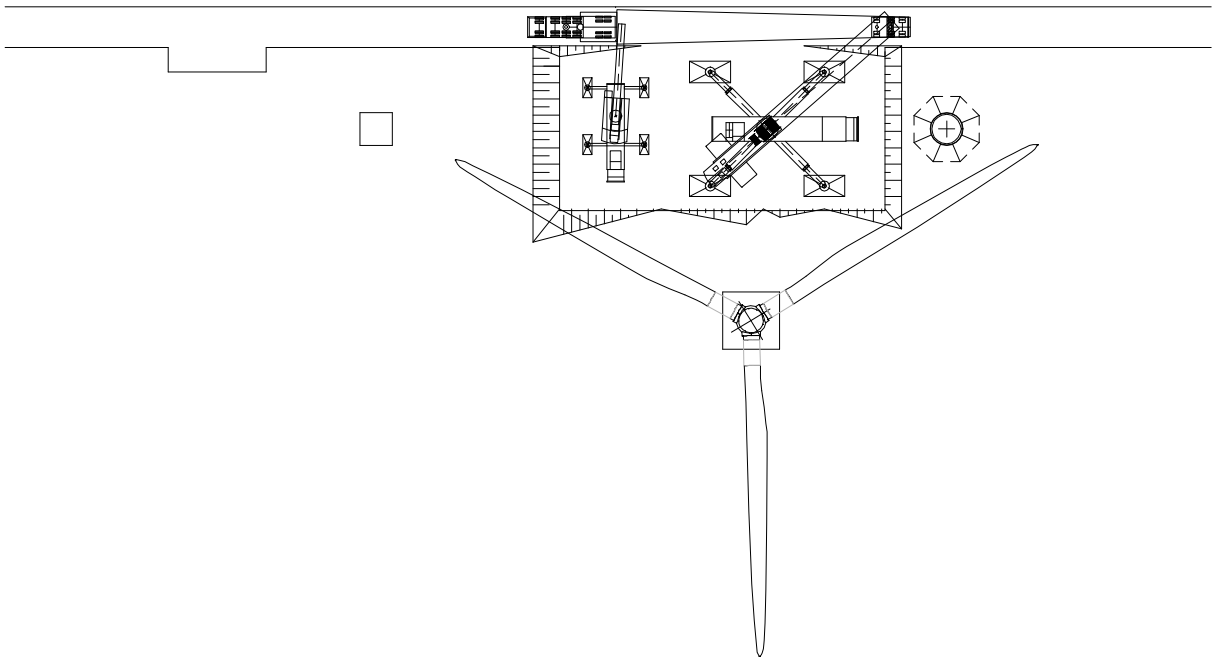


Figure 7 Mounting the turbine – tower. NB! Delivery of turbine parts from right, driving left.

Additional to the cranes following items will typical be positioned on the hard standing (or where possible)

- 2 X 20’ containers
- 10’ container (shelter)
- 5’ power unit

The items are not definitive and will depend on the logistics on the site.

4.1. Assembly area – hub

One hub and three blades are assembled on the ground to one complete rotor prior to the mounting. The rotor assembly requires a cleared area for the hub including blades and with a maximum gradient of 1:30. (see figure 8, left). Obstacles near the assembly area for the hub are to be removed according to agreement with Siemens Wind Power Project Department. At hill-sides, the rotor must be positioned down-hill.

A platform for the hub of dimensions minimum 7X7m and a minimum bearing capacity of 80kN/m² is required in a location allowing the rotor assembly to take place without the blades blocking the road.

As an alternative to rotor assembly on the ground, single blade mounting can be performed. If this method is chosen for the specific turbine location or the specific project, a platform for the hub will no longer be necessary.

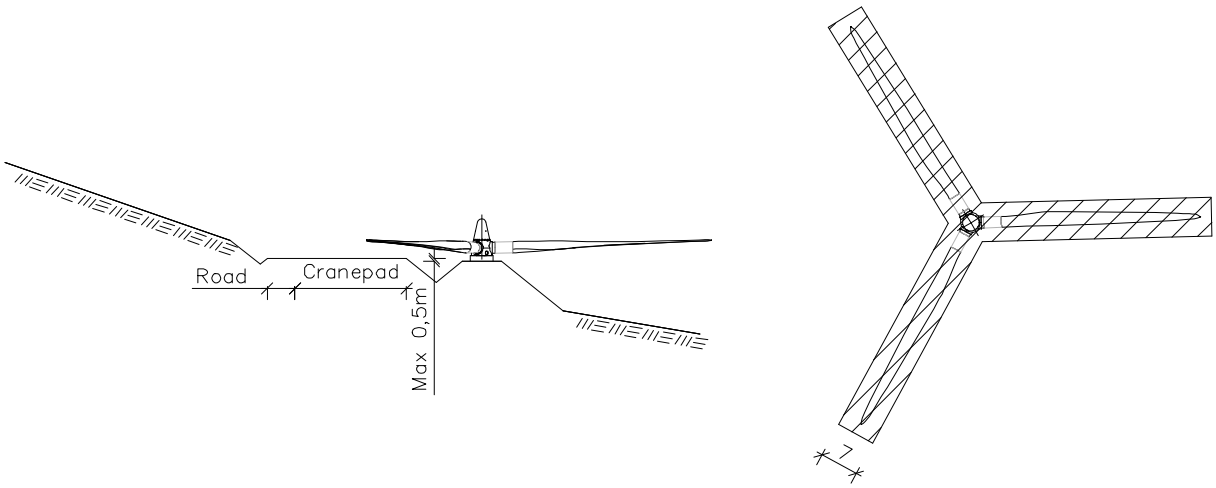


Figure 8 Cross sectional view of typical layout and requirements to assembly of the rotor on the ground. The hatched area on the right figure must be free for obstacles and have a max gradient of 1:30.

4.2. Hard standings and construction area

The hard standing area for a mobile crane / conventional crane or a crawler crane and the tailing crane should be 40X20m, in one level, with a max gradient of 1%. The bearing capacity should not be less than 200kN/m². It should be possible to position the main crane with a distance from centre slew point to centre turbine foundation of 18-26m meter, depending on the type of crane.
The level of the crane hard standing, H, should not be less than approx. 1m below the top of the turbine foundation.
Floating road principle must not be used for crane hard standings.

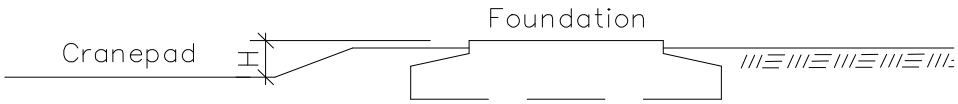


Figure 9 Hard Standings

If a mobile crane / conventional crane is chosen as main crane it will require an approx. 8X10m (road included) pad for the assist crane and an approx. 4X4m pad for a trestle to support the boom in a "horizontal" position, at each turbine location (figure 6 & 10).

If a crawler crane is chosen as main crane it will require at least one 8X10m (road included) pad for the assist crane and an approx. 4X4m pad for a trestle to support the boom in a "horizontal" position, at the first turbine location as well as at the last turbine location (figure 6 & 10). Depending on the site conditions the crane will move between the other turbine locations fully assembled.

The bearing capacity of both pads should not be less than 150kN/m². The exact position of

these pads varies according to the specific type of crane. The boom assembly area shall be relatively flat (obstacles +/- 750 mm) and have a max. Gradient of 1:10 (10%) in both directions.

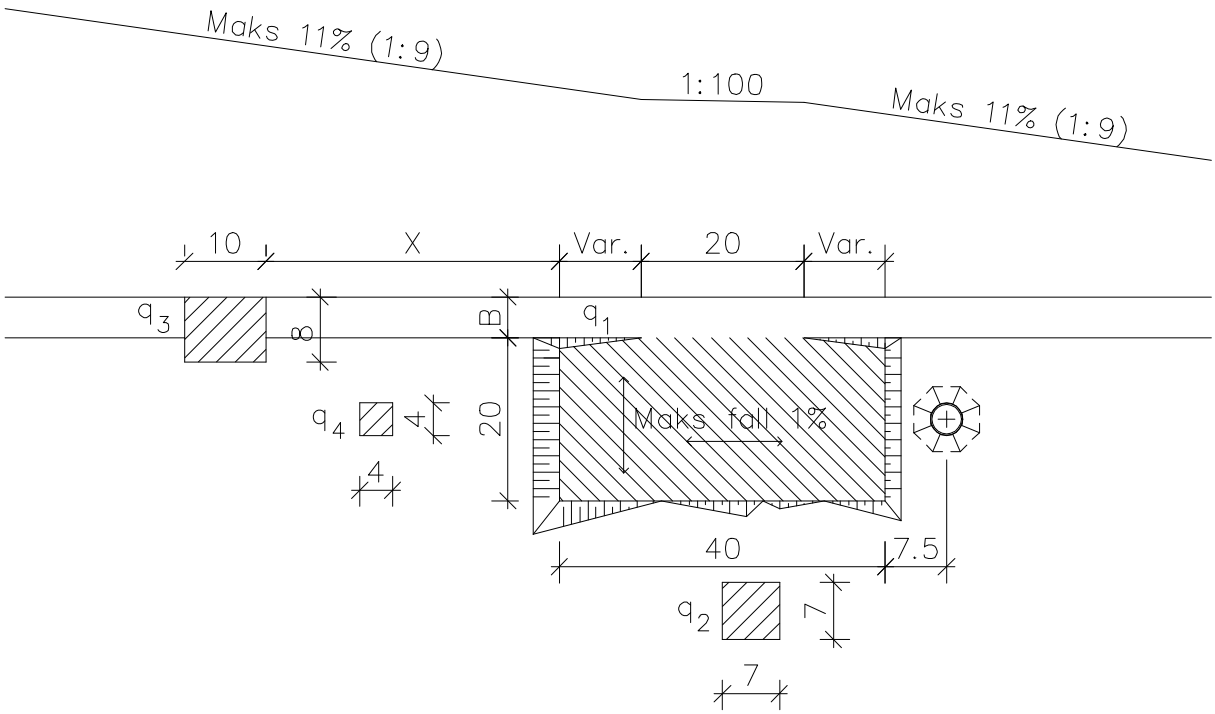


Figure 10 Hard Standings

	Dimension	Max fall	Bearing capacity
Hard standing – main crane	40X20m	1%	q1 ≥ 200kN/m²
Hard standing Assist crane	8X10 (road included)	As for roads	q3 ≥150kN/m²
Hard standing for support of the Boom	App. 4X4m	Relatively flat	q4 ≥150kN/m²
Rotor assembly area	7X7m	1:100 (1%)	q2 ≥80kN/m²

5. Requirements to storage

A storage area (lay down area) is required with the following specifications:

- It should be possible to transport components from the storage area to the site without any permission and in a way so the site manager can activate transport with short notice. The entrance roads to the storage area must fulfil the requirements as described in section 2.
- The size of the area, clearance and gradients are specified in the attached project specific information.

6. Compound area

A compound area must be provided with space for the following items, which are to be considered as typically but will depend on the size and logistic of the site:

- Parking area. Minimum 10 cars
- 20' container for tools
- 40' container for spare parts
- 40' container / changing room for site technicians
- Office for min. 6 persons
- 20' container for dangerous goods
- 10' power station
- Fuel area forklifts
- Sanitary facilities, Canteen

The list above is valid for sites where 5-40 turbines are to be installed. Any other agreements are listed in the attachment ‘project specific information’

7. Trial run

A trial run shall be carried out on site, at the earliest time following completion of the track roads, at the expense of the Employer. The type and configuration of the vehicle used for the trial run shall be agreed between the Employer’s Site Manager and the Contractor’s Site Supervisor. Any areas which as a result of the trial run require upgrade shall be agreed on site between the Employer’s Site Manager, the Contractor’s Site Supervisor and the Haulage Contractor and shall be upgraded at the expense of the Employer prior to turbine delivery commencement.

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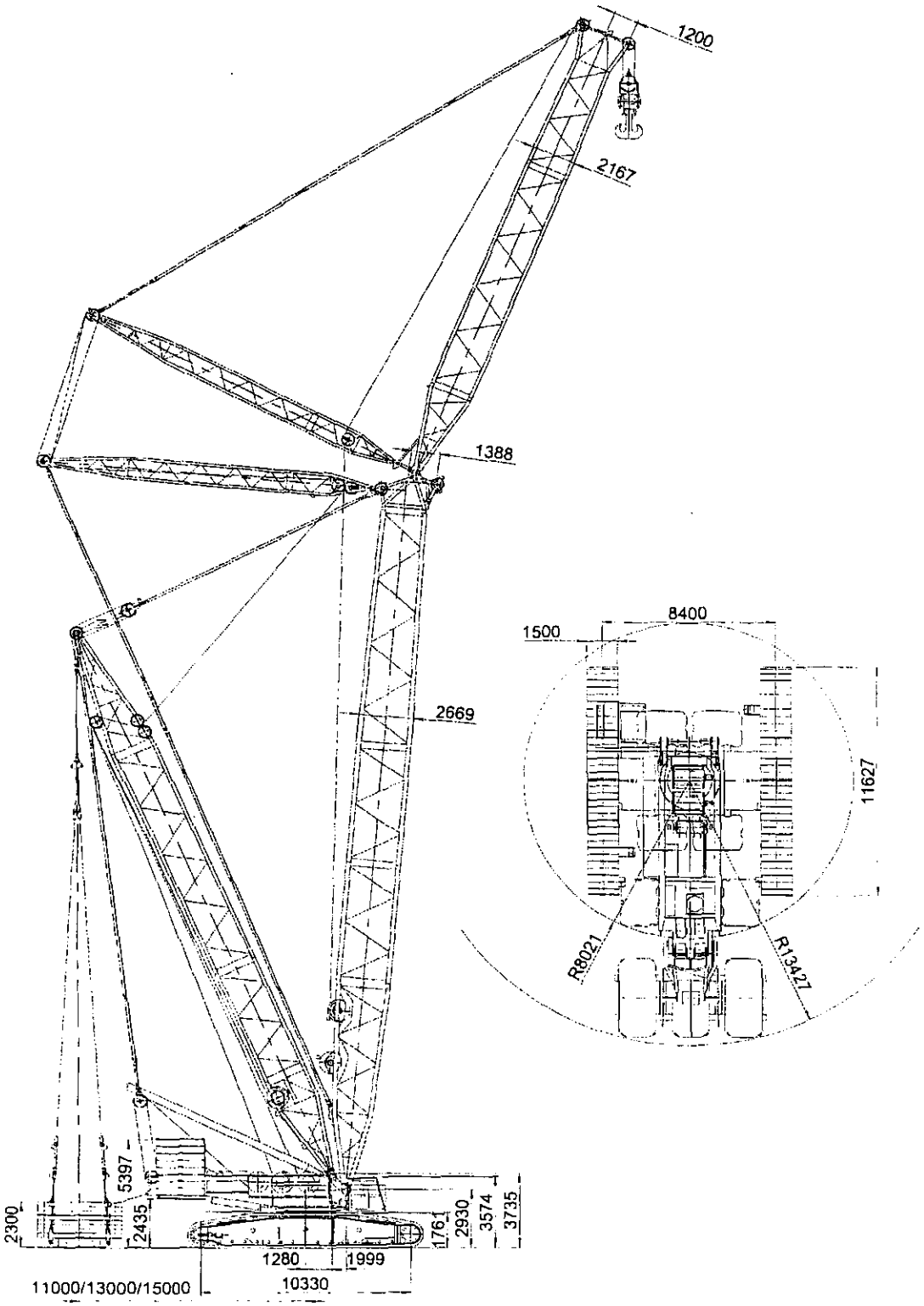

NB: Crane Supplier has yet to be selected.

Dimensions in millimeters
For reference only