

GE Energy

# Technical Documentation

## Wind Turbine Generator Systems

### 2.5-2.75 Series



## Specification

### Site Roads and Crane Pad



imagination at work

All technical data is subject to change in line with ongoing technical development!

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## 1 Requirements

This specification describes the major dimensions and weights of the vehicles required for transportation of the main components of the GE 2.5-2.75 Series Wind Turbine Generator System (WTGS). Furthermore, the minimum requirements (based on normal ground conditions) for access roads and crane pads described herein must be met to ensure the proper installation of the WTGS.



Please note that additional measures may be necessary in the event of deviant conditions!

## 2 Transport Vehicles (examples)

- 15 heavy-duty trucks for erecting and dismantling the crane
- 13 heavy-duty trucks with plant components consisting of:
  - o 1 for tower base ring
  - o 2 for PPM system
  - o 4-5 for tower sections
  - o 1 for nacelle
  - o 1 for hub
  - o 3 for rotor blades

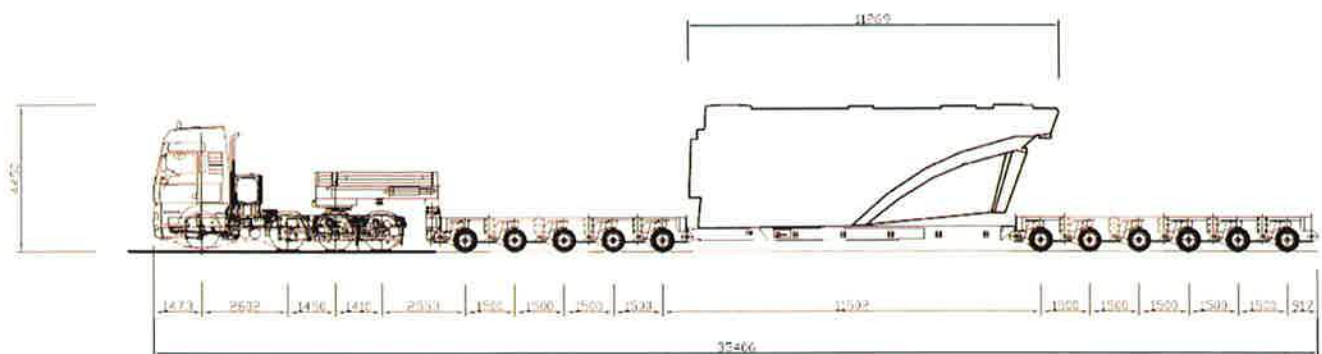


Figure 1: Example of transport vehicle for the nacelle

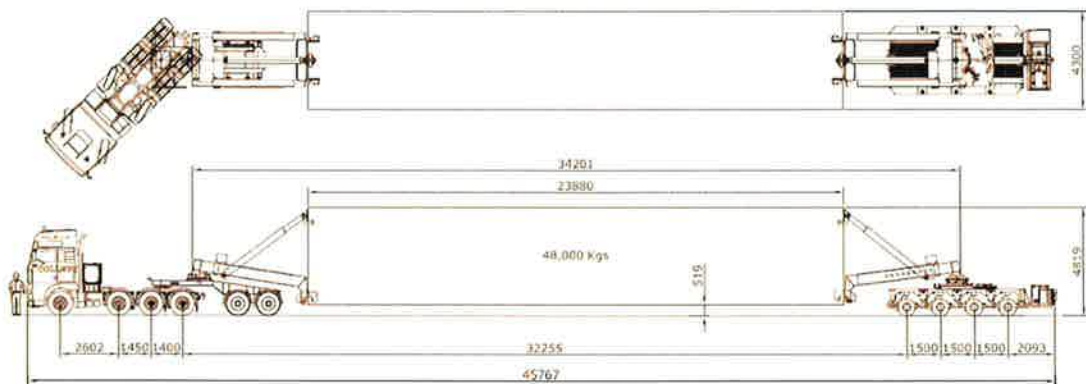


Figure 2: Example of transport vehicle for the tower sections

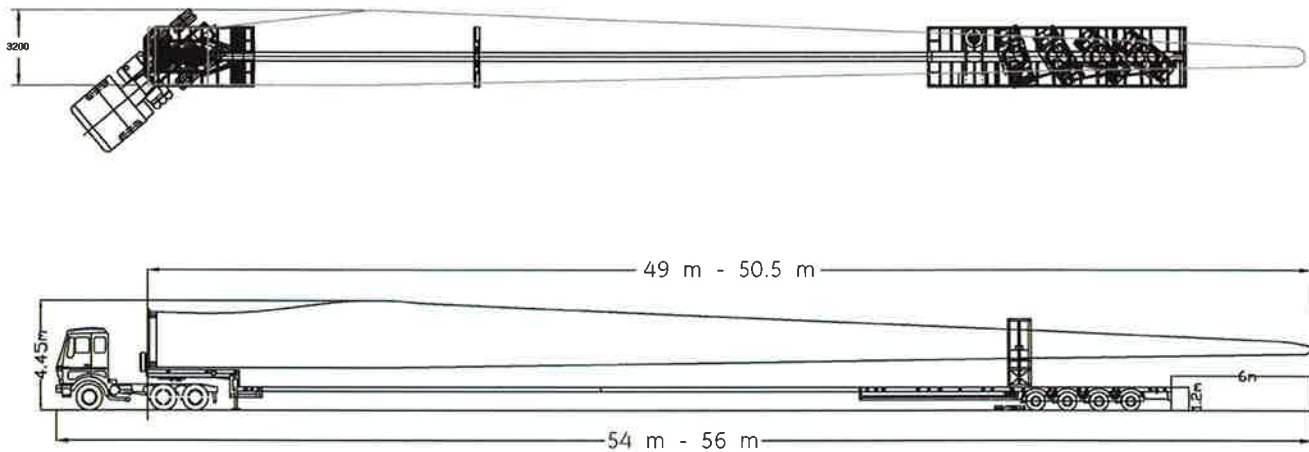


Figure 3: Example of transport vehicle for the blades

The equipment and dimensions may vary due to availability. The maximum vehicle length is 56 m when loaded with the rotor blade. The vehicle length is measured from the front of the transporter to the end of the load.

## 2.1 Vehicle Weights

- Maximum axle load 12-16 t, onsite for cranes and transport vehicles
- Maximum individual weight approximately 140 t

### 3 Access and Site Roads/Entrances

#### 3.1 Road Curves and Entrance Curves

The road curves and entrance curves must be constructed to the dimensions shown in the figures below. The dimensions are based on the rotor blade transport vehicle due to the fact that this vehicle requires the most compacted area to pass the curves.

All stored and excavated topsoil or any obstacles in the areas next to or near the road or entrance curves must be removed or leveled before turbine delivery can begin. All open cable trenches that run along the roads or crane pads must be refilled before any turbine delivery and construction can begin.

GE Energy will not take responsibility for any damage to the roads that has been caused by the transport vehicles or cranes when the access roads or site roads have not been properly constructed. This will apply also for damage caused to vehicles due to unsuitably constructed roads, waiting time, or recovery costs.

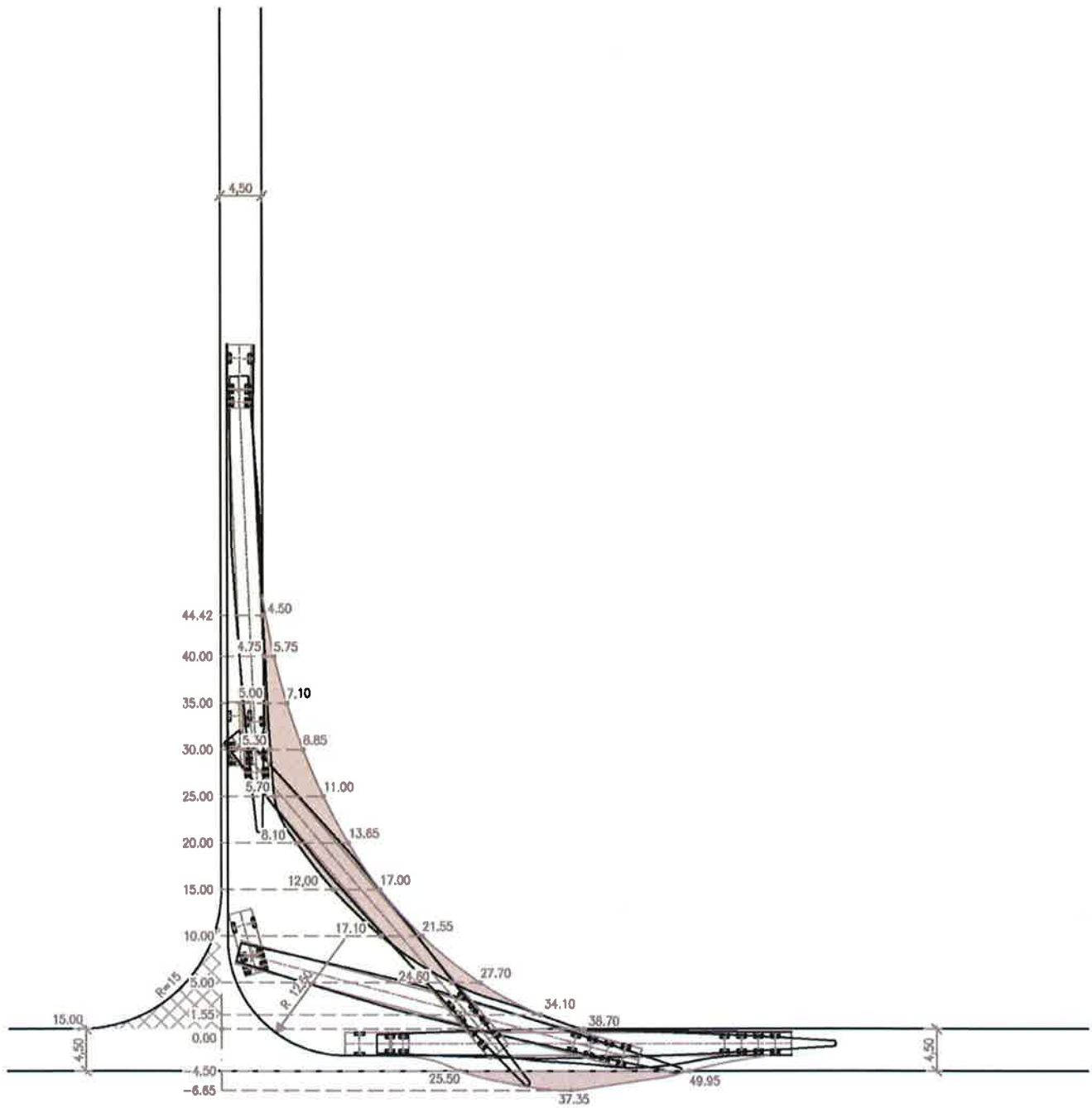
#### 3.2 Turning Curves

The curve radii for transportation vehicles can be obtained from the following drawings:

- Figure 4: Truck with rear axle steering, outside radius 12.5m / turning angle 90° on page 8
- Figure 5: Truck with rear axle steering, outside radius 32.5m / turning angle 90° on page 9
- Figure 6: Truck with rear axle steering, outside radius 12.5m / turning angle 120° on page 10
- Figure 7: Truck with rear axle steering, outside radius 32.5m / turning angle 120° on page 11
- Figure 8: Truck with rear axle steering, outside radius 32.5m / turning angle 150° on page 12
- Figure 9: Truck with rear axle steering, outside radius 32.5m / turning angle 180° on page 13



Please note that additional measures may be necessary in the event of deviant conditions or equipment used!



**legend**




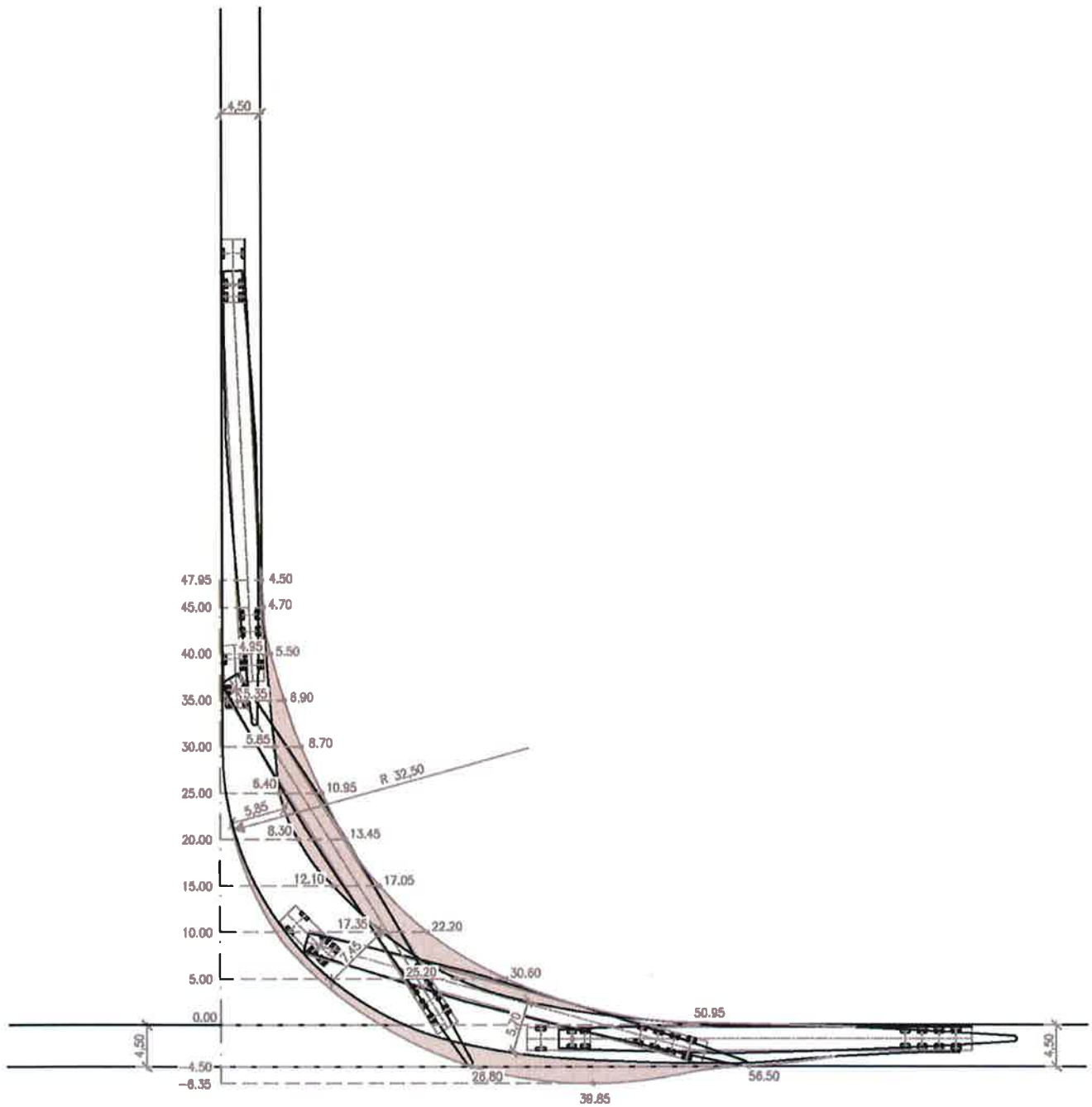
-  compacted area
-  area free from obstacles
-  optional reversing area

Figure 4: Truck with rear axle steering, outside radius 12.5m / turning angle 90°





**Legend**

compacted area

area free from obstacles

Figure 5: Truck with rear axle steering, outside radius 32.5m / turning angle 90°





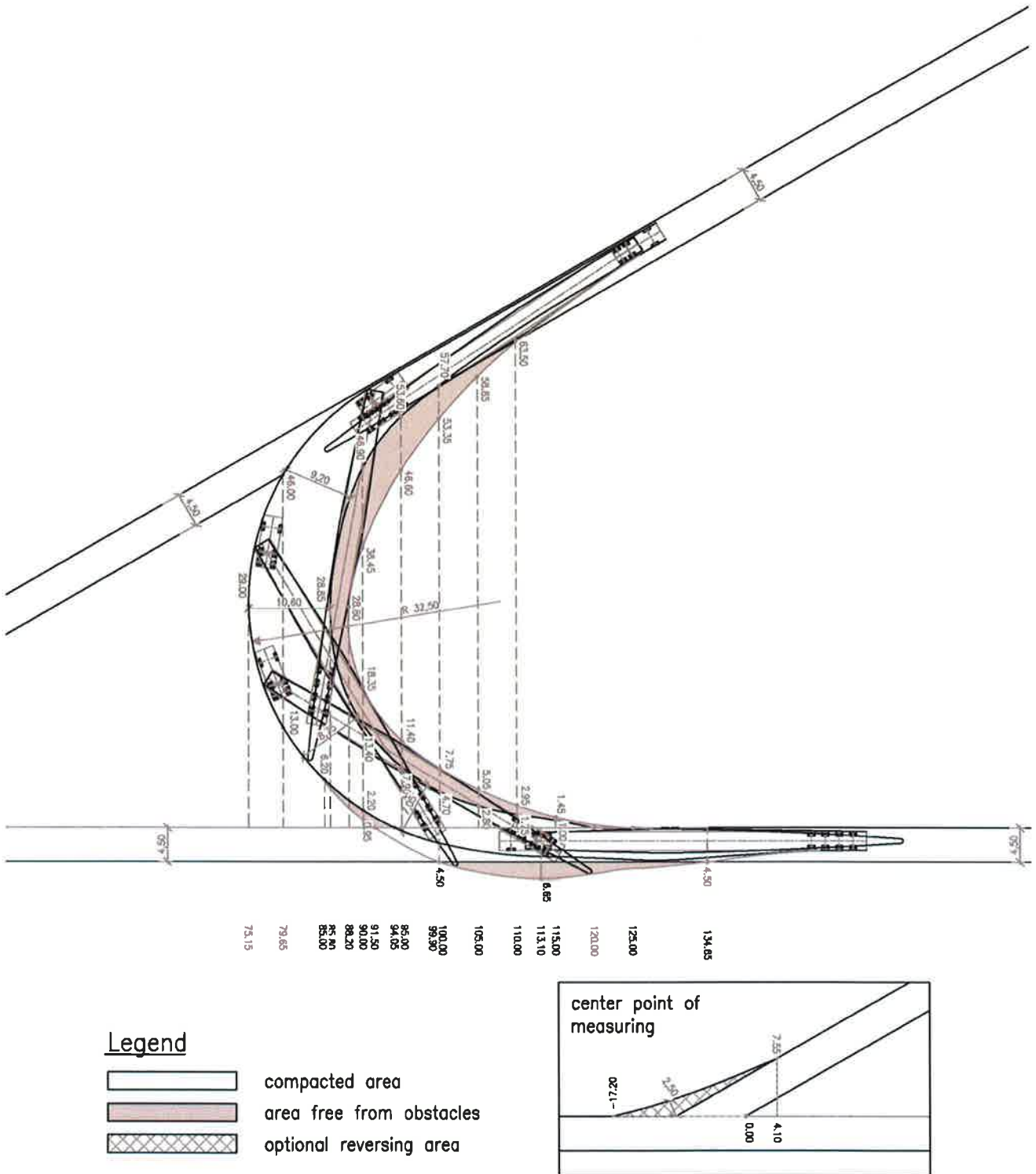
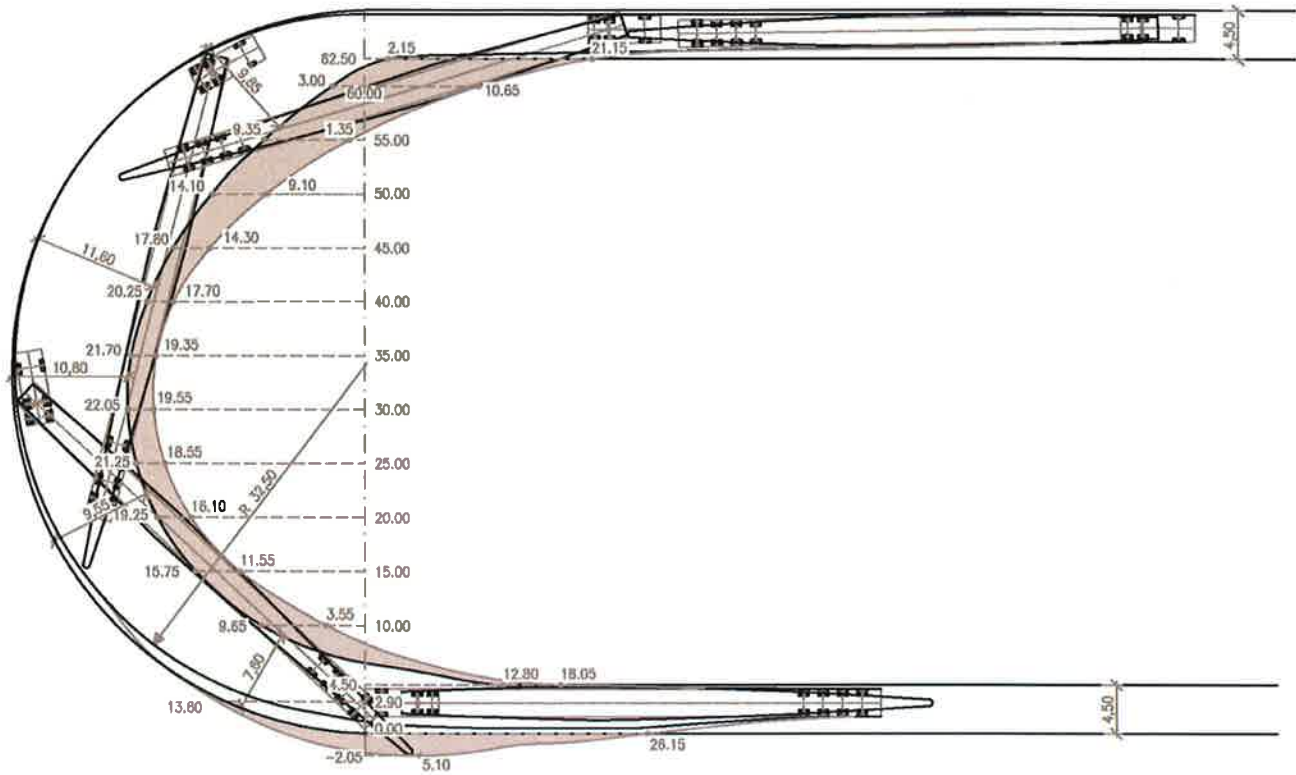


Figure 8: Truck with rear axle steering, outside radius 32.5m / turning angle 150°



**Legend**

- compacted area
- area free from obstacles

Figure 9: Truck with rear axle steering, outside radius 32.5m / turning angle 180°

### 3.3 Gradient

In general the transport vehicles will be able to access gradients up to 6 % on straight roads without narrow bends and under good weather and road surface conditions. It is possible to transport the turbine components on gradients over 6 %. In those cases there will be a necessity for one or more towing/pushing vehicles to be supplied.

If during project planning it is seen to be necessary that a towing vehicle is required for gradients over 6 %, GE Energy and the customer will decide on the type of towing/pushing vehicles and the suitable towing procedure with regard to the respective situation. All costs for ordering, delivery and use of the towing/pushing vehicles are to be paid by the customer.

If during project planning it is seen to be necessary that a towing vehicle is required for gradients under 6 % it is to be supplied by the customer at short notice. Reasons for this may be, but are not limited to:

- bad weather conditions
- poorly constructed roads etc.

All costs resulting from the need for a towing/pushing vehicle during the project phase and those costs resulting to waiting time for GE Energy and its crane/transport vehicles will be passed on to the customer.

### 3.4 Road Camber

Access and site roads should have a maximum camber of 2 % for proper drainage.

### 3.5 Clearance, Height and Width

The customer has to ensure that on all access and site roads any overhanging tree branches, powerlines and telephone cables are removed to avoid damage to turbine components.

Minimum height = 6.0 m, minimum width = 5.0 m according to Figure 10.



The equipment may vary due to availability or transport strategy.

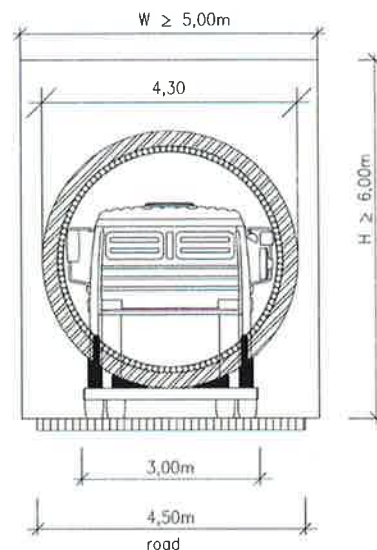


Figure 10: Clearance, onsite tower transport as example



### 3.6 New Site Roads

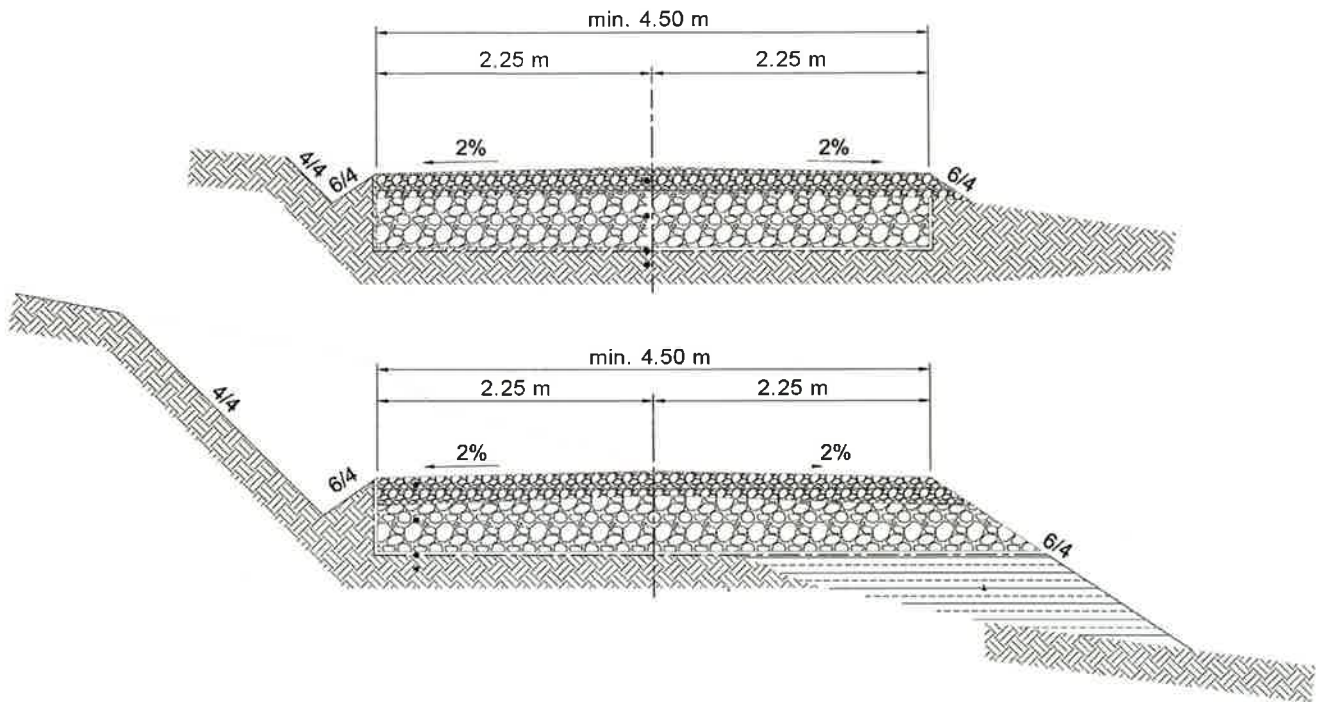


Figure 11: New site road (example)

All site roads must be constructed to the minimum drivable width of 4.5 m. The roads must be constructed with a camber of 2 % (maximum), so that rainwater can flow off and hence the risk of rutting/potholes is reduced.

It is important to note that the method of road construction and the gauge of the base layers is solely dependant on the local ground conditions.

The base layer can be a rock-gravel-sand mix 0/45. For the top surface a mixture of rock-gravel-sand 0/40 can be used. The thickness of the respective layers will depend on the required axle loading and the existing ground conditions. GE Energy suggest that the customer obtain an expert opinion or recommendation. All layers of material are to be mechanically compacted. A layer of geotextile has to be inserted in order to prevent silting or compression of the construction layers and the subsurface.

If impurities in recycled construction materials (sharp rocks or metal particles in re-cycled stone) lead to damages to transportation vehicles (tire damage etc.) the resulting costs will be passed on to the customer.

Due to the limited ground clearance of the transport vehicles special care needs to be taken during road construction that all sharp humps and bumps are removed (see section 3.8 on page 17).

GE Energy underlines the fact that especially under bad weather conditions the site roads have to be checked continuously. Upgrading measures and repair work on access roads have to be carried out during the project delivery phase and immediately if required.

### 3.7 Upgrading of Existing Roads

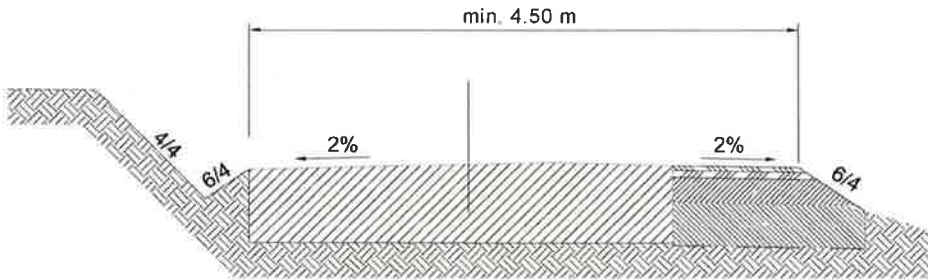


Figure 12: Upgrading of existing roads (example)

If existing private/public tarmac or concrete roads with a drivable width less than 4.50 m have to be used as site roads then these roads are to be widened. In carrying out these measures and construction works all points made under Figure 12 above have to be considered.

The widening of the roads is required for safety reasons. It reduces the risk of the road edges breaking off, since vehicles and cranes with a track width of 3.00 m and a total weight of maximum 140 t have to be employed to ensure the delivery and erection of the WTGS. If drainage ditches run directly along the sides of such roads, special safety measures must be taken.

If during the project delivery breakages begin to show, specific safety measures must be taken to prevent lateral phase cracks displacement. Any costs to GE Energy resulting from “waiting time for repair works” in regard to transport and erection of the WTGS will be passed on to the customer.

GE Energy proposed the following test to evaluate the final condition of the road and to ensure the ground bearing of minimum 12 t axle load for the Transport vehicles. This should also include wet site road conditions.

#### Plate Load Bearing Test of the Construction Layer

According to the size of the loads having an effect on the ground a distortion module is to be assigned to the subsoil. This distortion module, also called Ev2 value, can be checked by a plate load-bearing test. As a reference the German Institute for Standardization can be used: DIN18134. The relation of Ev1 / Ev2 must be smaller or equal to 2.5. An improvement of the subsoil or the construction layer will be necessary if the Ev2 value is smaller than in following table:

Value of the max. single load in kN (t)	Ev2 in MN/m <sup>2</sup> of the subsoil	Ev2 in MN/m <sup>2</sup> of the construction layer
≤ 60 (6.0)	≤ 45	≤ 100
≤ 100 (10.0)	≤ 60	≤ 120
≤ 150 (15.0)	≤ 80	≤ 150
≤ 200 (20.0)	≤ 100	≤ 180

The minimum value for transportation is a single load of 6.00 t per tire.



### 3.8 Ground Clearance of Transport Vehicles

When constructing the site roads care must be taken to try to keep the gradients of any hills to a minimum. The requirements are explained in Figure 13.

Extra care must be taken to make sure that any sharp road humps along the site roads and access routes are leveled out to reduce the risk of the vehicles grounding and damaging the components and their vehicles.

The overall height of the vehicles employed for the transportation of the tower sections has to be as low as possible. The ground clearance for such vehicles is 20 cm. Therefore, it has to be considered already at the planning stage that depressions and ridges in the access roads are filled in and leveled.

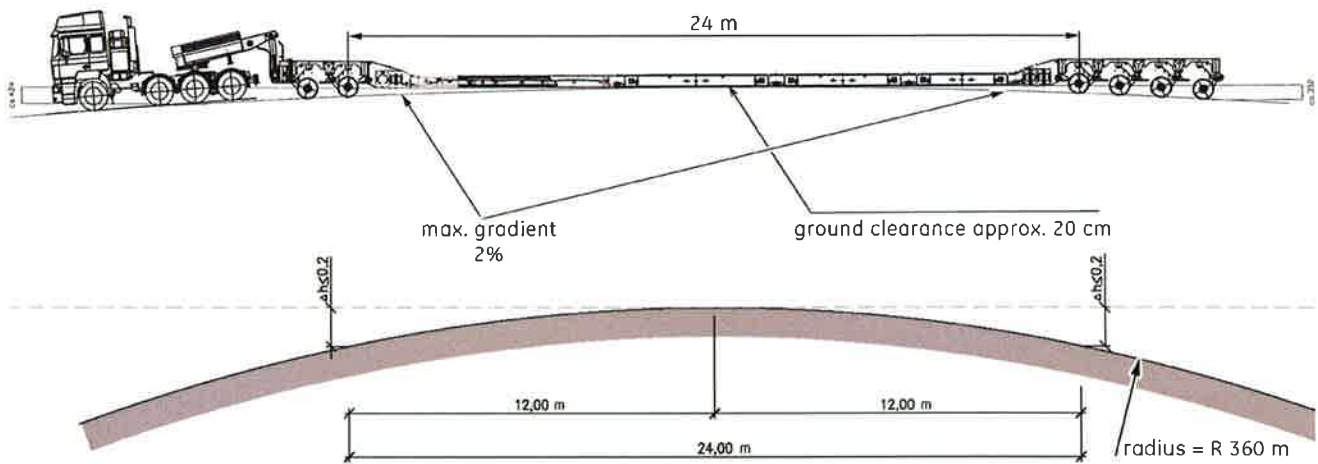


Figure 13: Ground clearance (example)

## 4 Crane Pad

The crane pads must be constructed as shown in Figure 14 to Figure 18. Both wheel-mounted and crawler-mounted cranes can be used. For the mobilization of those cranes the axle weight will be 12 t.

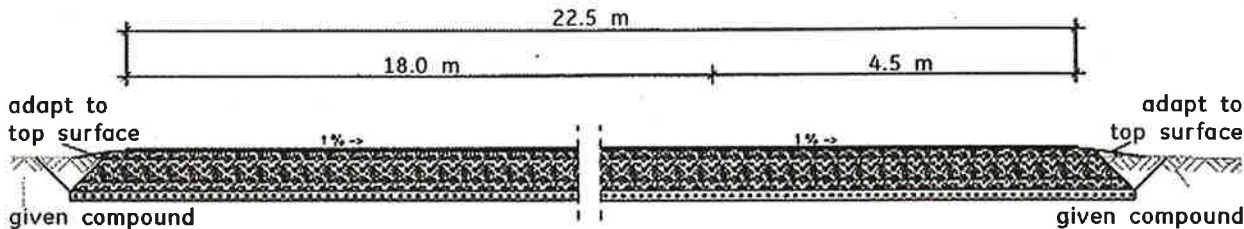


Figure 14: Cross section crane pad

All crane pads must be at-grade with a maximum slope of 1 % of the total length and width of the entire area.

Soil and obstacles may not be deposited around the crane pad or for a distance of 130 m along the site road. This area is required for the assembly of the crane boom.

A 2 m wide gravel path must be constructed from the crane pad/road to and around the turbine to prevent soiling of the plant.

The areas with a width of 10 m on the right and left of the crane pads are used for assembly of the rotor and storage of the plant components (see Figure 20 and Figure 21). Permission for the use of these areas will have to be obtained by the customer from the landowner and submitted to GE Energy before the erection phase starts.



**Any variations to the above are only permissible with the approval of a representative of GE Energy.**

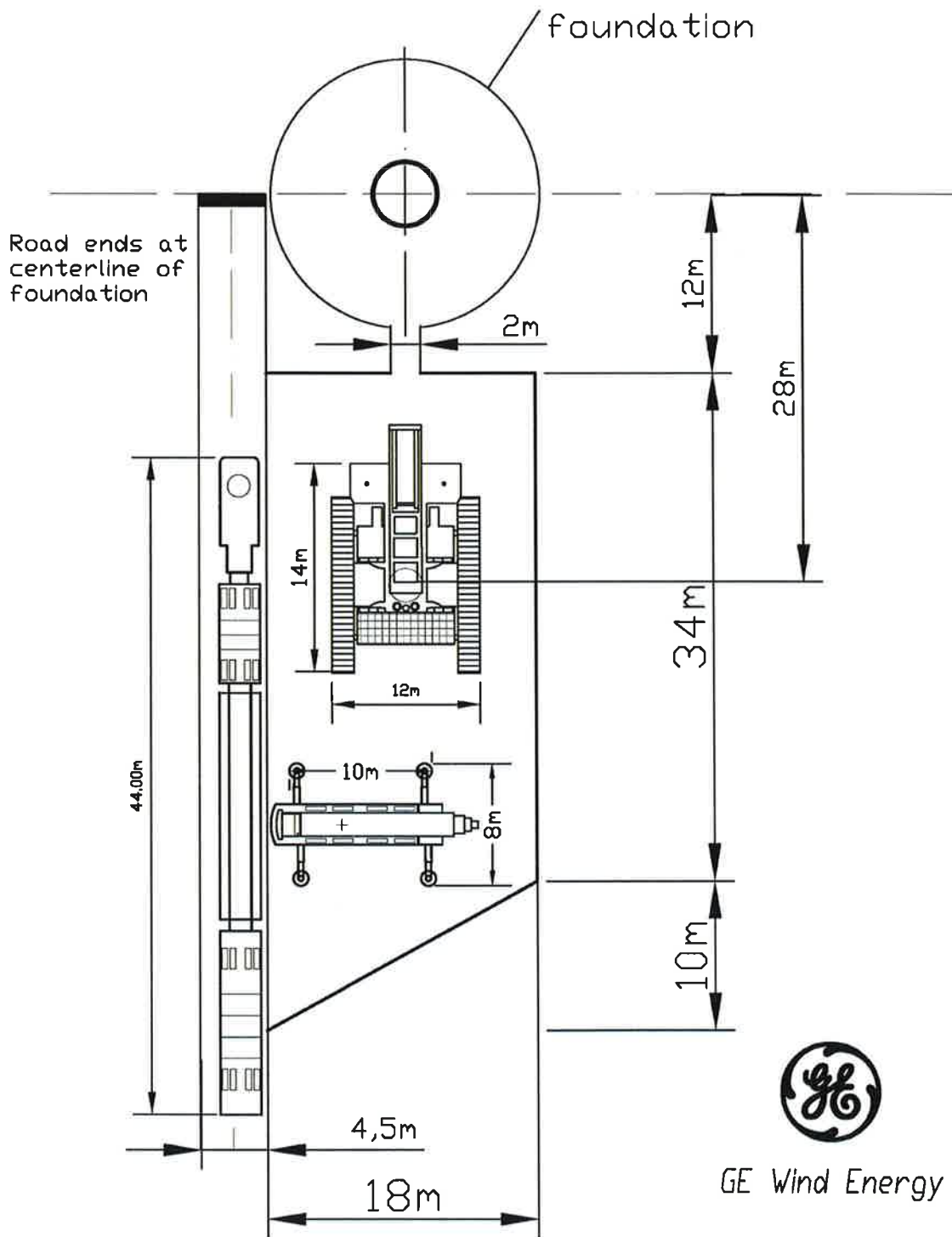


Figure 15: For hub height up to 100 m - option 1 with crane pad alongside the access road, crane and truck positions, max. slope 1 %

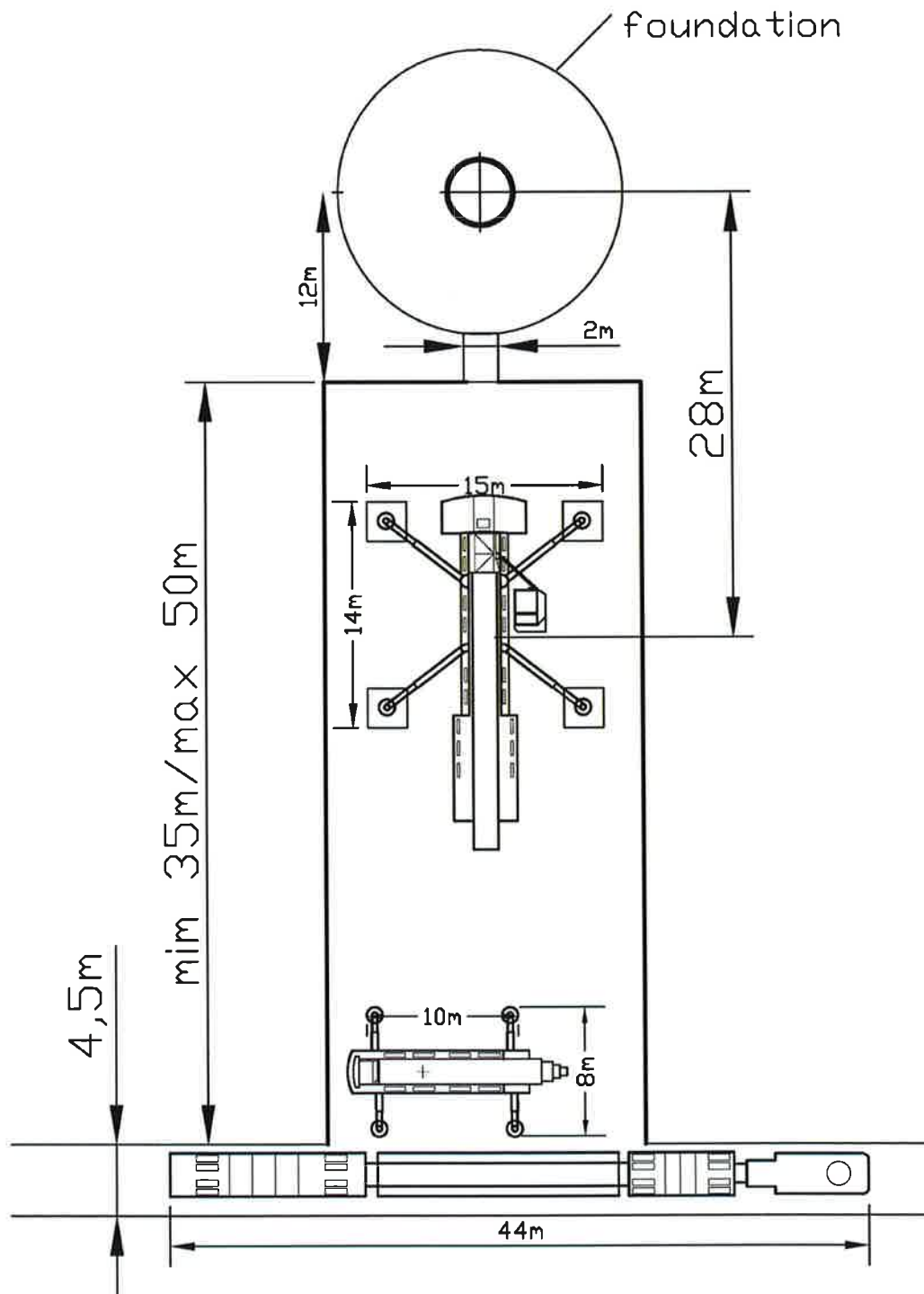


Figure 16: For hub height up to 100 m – option 2 with crane pad perpendicular and max. distance between foundation and access road, crane and truck positions, max. slope 1 %

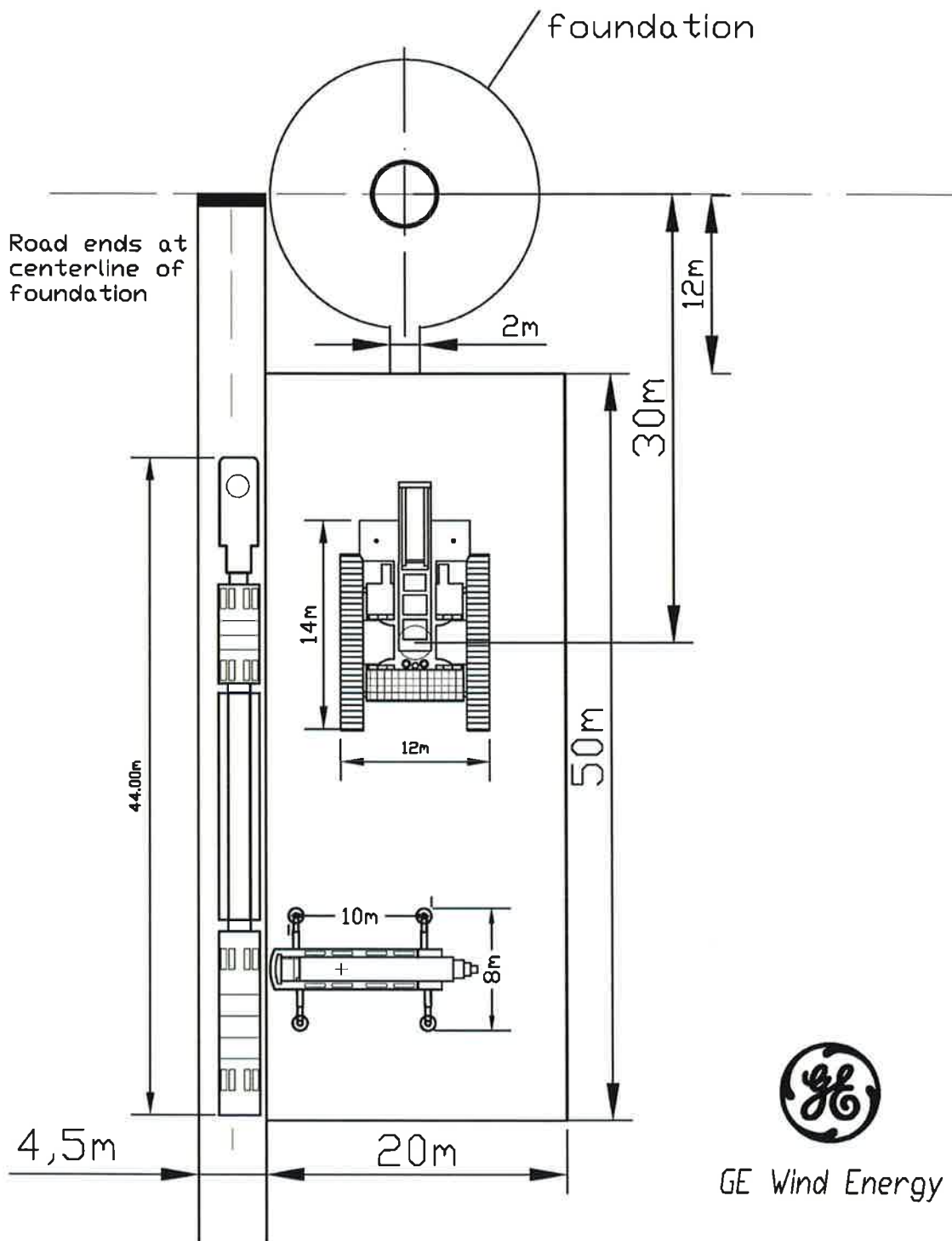


Figure 17: For hub height up to 140 m – option 1 with crane pad alongside the access road, crane and truck positions, max. slope 1 %

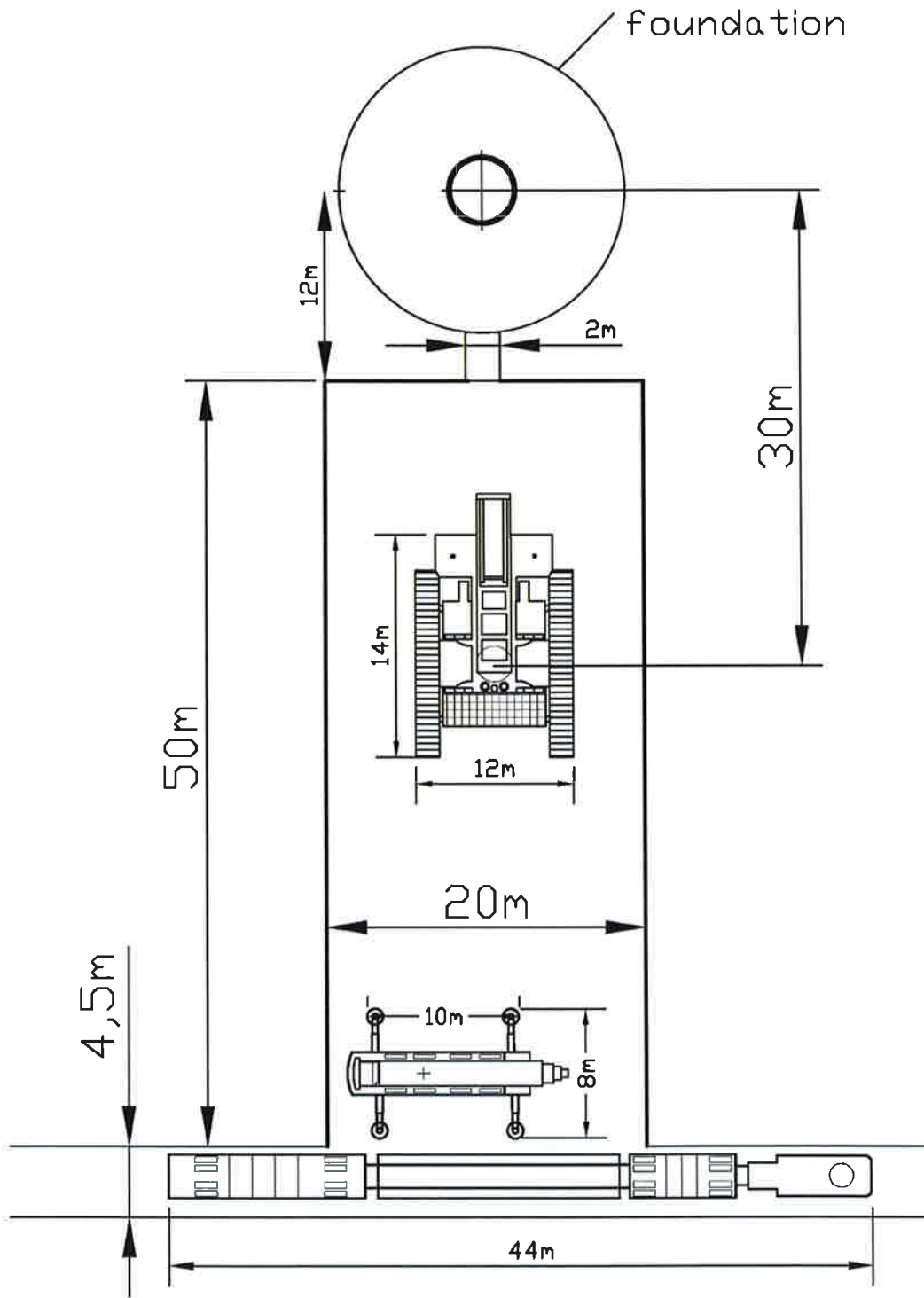


Figure 18: For hub height up to 140 m – option 2 with crane pad perpendicular and max. distance between foundation and access road, crane and truck positions, max. slope 1 %

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## 5 Parking Area / Turning Area

### 5.1 Parking Area

Parking areas for at least four component transport vehicles with a length of 50 m and a width of 5 m have to be made available within the windfarm area. If the vehicles will be required to park on public roads or highways then the required permits, signs and lighting will have to be obtained from the appropriate authorities by the customer. These permits will be required before transportation activities start.

### 5.2 Turning Area for Unloaded Vehicles

GE Energy suggests to the customer that at certain areas within the windfarm, turning-areas for the vehicles shall be included in their planning. These areas will firstly allow the vehicles to keep to the designated site roads and reduce the amount of time that they will need for reversing out of the windfarm. Secondly it will reduce the risk of vehicles getting stuck or causing damage.

## 6 Soil Backfilling/Foundation Area

During the installation of the WTGS an area of 10 m around the foundation ( $\varnothing$  9 m) is needed for the usage of an all-terrain forklift for the installation of turbine equipment outside the tower. This means that if soil backfilling is required due to the foundation design the finish of this work scope has to be done after the turbine is erected.

A gravel path of 2 m width must be constructed from the crane pad/road to and around the turbine to prevent soiling of the plant.

## 7 Crawler Crane Movements on Site

If it is planned to use a crawler crane moving on site directly between the turbine unit locations the following points needs to be considered.

- Permits/permissions (from landowner) to move with the crawler crane directly over the land between the several turbines locations shall be obtained by the customer
- Crane pad level of 1 % gradient maximum in all directions
- Crane pads need to be accessible for the crawler crane
- Lateral inclination during movement of the crane: Maximum 2 % gradient
- Free (drive-through) area needed to move between the several turbines locations is 12 m
- There are two options to move the crawler crane:
  - o Option 1: One track in the middle of the site road (4.5 m wide), and the other track in the area beside the road (10 m wide)
  - o Option 2: Use the free land to move the crane directly between the turbine locations
- Max. slope in moving direction is approx. 10 %
- Free area of 10 m x ? m (length of the crane boom) for the assembly of the crane boom at the first turbine and disassembly at the last turbine
- Ground pressure under the tracks as, for example, for a Liebherr LR 1600 is approx. 220 kN/m<sup>2</sup>. Ground pressure can vary due to different crane type



Please note that additional measures may be necessary in the event of deviant conditions!

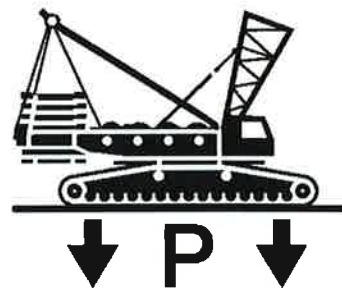


Figure 19: Ground pressure under the tracks

## 8 Site Compound

GE Energy will require a hardstanding to be constructed by the customer for use as a site compound. This area needs to be leveled and constructed with clean fine gravel stone. GE Energy will place site containers, toilets and equipment in this area and will therefore require electrical connections and waste water collection. The required dimensions of this area are minimum 20 m x 20 m for a windfarm size up to 20 units. GE Energy will give details as to its position within the windfarm in cooperation with the customer at a later date.



Any variations to the GE Energy specification may only be carried out after they have been discussed and approved by GE Energy.





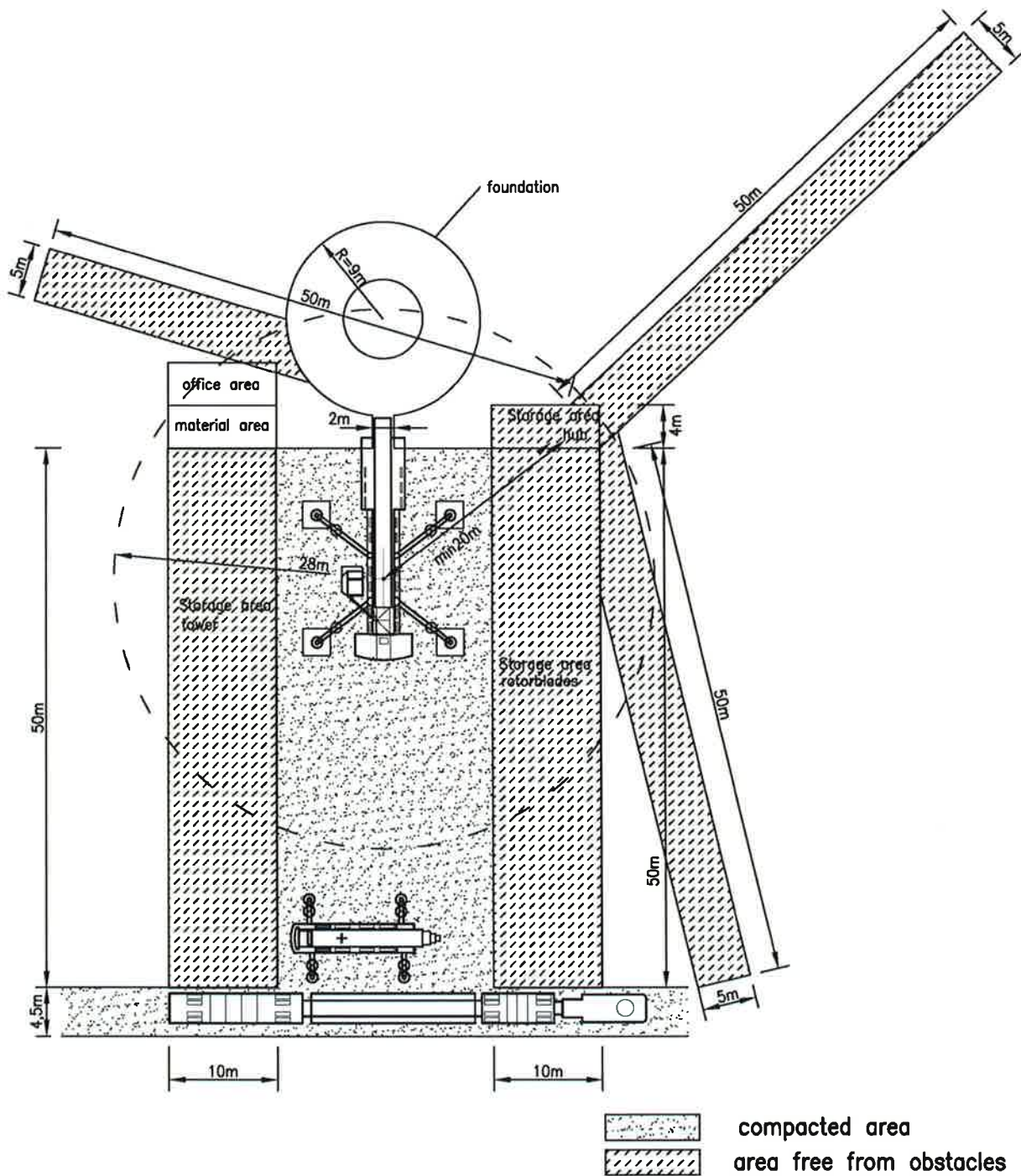


Figure 21: Option 2, perpendicular, with maximum distance between foundation and access road



The layout and position of the storage/assembly area can vary due to local surroundings and different hub heights

## 10 Crane assembling area

For the assembly of the main boom/jib of the main crane a free area must be provided. This area needs to be accessible for the assisting crane which will always be required. The assisting crane will also require a plain area beside the site road, or along the direction chosen for the assembly of the main boom/jib.

Shown below are some examples of the types of cranes that can be used for the installation of the turbines as well as details of the areas required for the assembly of the main boom/jib and assisting crane. The requirements listed below are based on a stable terrain with a specified maximum gradient/decline for the assembly of the main boom/jib. If the conditions below cannot be achieved, then project specific options will need to be discussed and implemented.

### 10.1 Crawler Crane with Lattice Main Boom

- Required area for assembly 130 m x 10 m
- Maximum gradient/decline for main boom/jib assembly 8 % uphill
- Clear and flat areas for assisting crane 10 m x 10 m

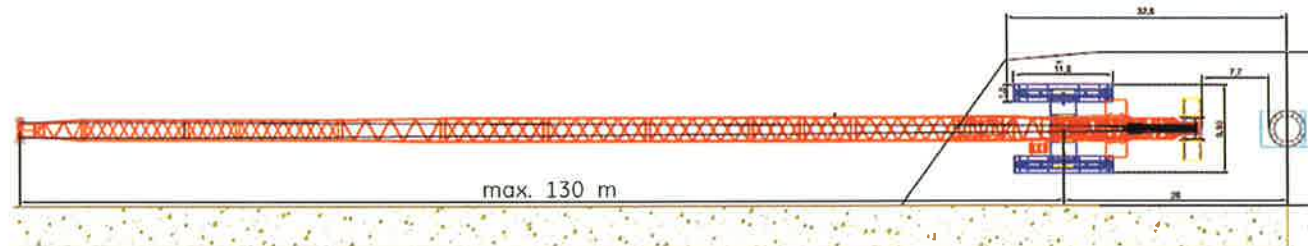


Figure 22: Crawler crane with lattice main boom

### 10.2 Telescopic Crane with Lattice Jib

- Required area for assembly 90 m x 10 m
- Maximum gradient/decline for main boom/jib assembly 8 % uphill
- Clear and flat areas for assisting crane 10 m x 10 m

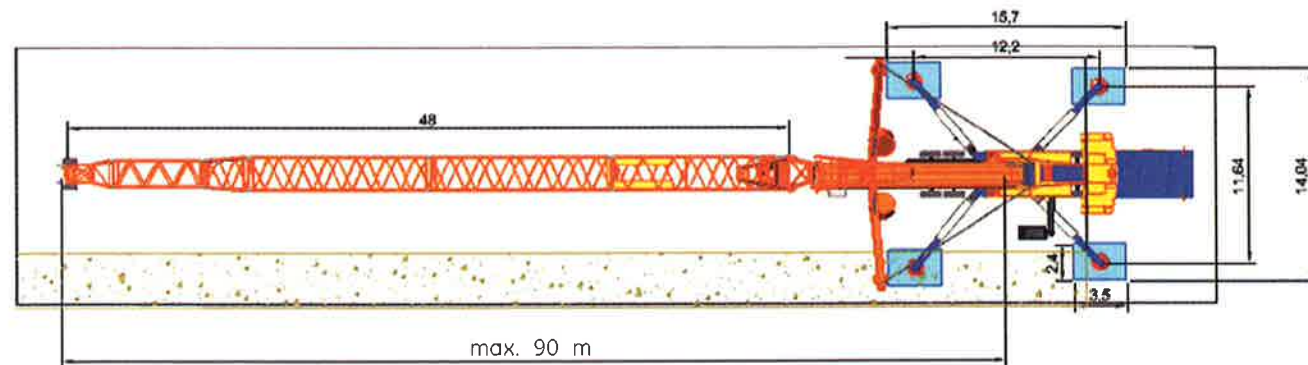


Figure 23: Telescopic crane with lattice jib

### 10.3 Wheeled Crane with Lattice Main Boom

- Required area for assembly 130 m x 10 m
- Maximum gradient/decline for main boom/jib assembly 8 % uphill
- Clear and flat areas for assisting crane 10 m x 10 m

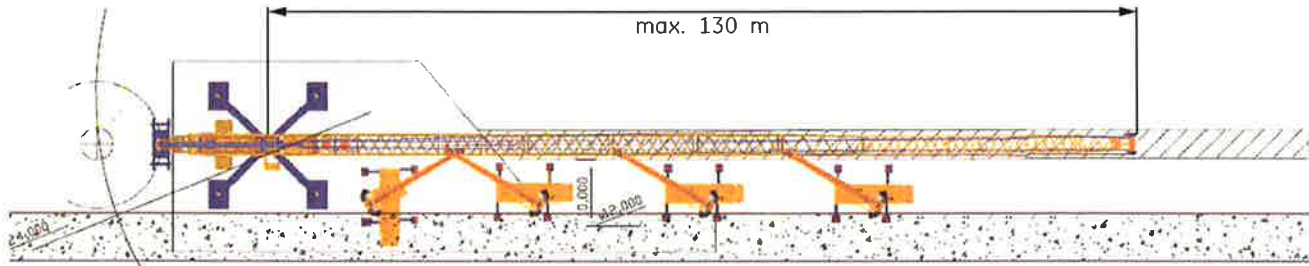


Figure 24: Wheeled crane with lattice main boom



The required area for assembly of the crane boom can vary due to different hub heights, equipment used and to local surroundings. These drawing are only to be used as an example.

Crane boom assembly downhill is complicated and may not be possible. If the assembly of the boom cannot be carried out on a plain or uphill area please contact project management for further instructions.