**IPA Project: POWERED**

**Technical Document: N.01**

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# WIND MEASUREMENTS TOWER

# - GUIDANCE AND SITING -

## Introduction

This guidance document describes the requirements concerning the siting of meteorological mast for wind measurements. As general rule, meteorological sensors should be sited at a distance beyond the influence of obstructions, such as buildings and trees; this distance depends on both the variables to be measured and the type of obstruction. The other general rule is that the measurement should be representative of meteorological condition in the area of interest; the site accessibility and safety must be taken into account in order to guarantee maintenance of the measurements station.

## 1. Representativeness

The site selection for tower placement should address the question : "Is the site (and the area) representative ?". Representativeness is defined as "the extent to which a set of measurement taken in a space-time domain reflects the actual condition in the same or different space-time domain taken on a scale appropriate for a specific application". In general, the location of tower should be representative of meteorological conditions in the "area of interest".

Proper site selection is critical to obtaining representative meteorological data. In order to minimize absolute error, correct site selection is much more important than proper placement of individual pieces of air monitoring equipment. Poor placement can cause wind direction errors up to 180° and can cause major errors in any others meteorological variables, including wind speed, temperature, humidity and solar radiation.

Proper siting is an essential part of a total quality assurance program. Ideal siting may not always be possible attainable, such as in many urban areas where air quality studies are traditionally made and it is quite impossible to find a site that meets all air quality and meteorological siting criteria; so an accurate data evaluation is crucial to understand the real behaviour of the wind.

## 2. Wind Measurements Tower

Towers are the most advantageous platforms for continuous measurements and to assure good quality for meteorological data, they should be located in an open, level area. In regions with complex terrain structure (large terrain inclination and inhomogeneous terrain) and in transitional regions between land and sea, different flow patterns may occur varying the measurement height;

more than two planes of measure are requested in order to reduce the errors induced by the vertical gradients.

Tower construction should be an open grid (lattice tower) and the mast section could be triangular or square; enclosed towers, stacks, water storage tanks, grain elevators, cooling towers and similar structures should not be used.

*Fig. 1: typical lattice tower module*

Towers must be rugged enough to be climbed safely, to install and service the instruments. In order to give a good quality of meteorological data profiles, the wind masts should have a minimum height (h) of 45 meters. To increase structural hardiness, steel towers are preferred and they should be secured with at minimum three groups of wind-bracings equally distributed around the tower. Depending on the tower height, each group of wind-bracing could be anchored on one or two foundation in concrete; the two configurations are shown on Fig. 2.

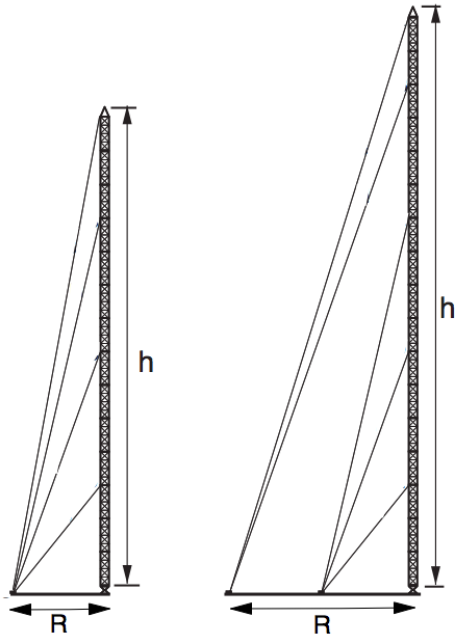


*Fig. 2: typical wind-bracing configurations for lattice towers. Left is the one-anchor type, right the two-anchors*

The concrete used for foundations blocks should have minimum characteristics load of 15 N/mm$^2$

and each footing should have upper and lower iron reinforcement. Typical foundation for wind tower are shown in fig. 3, while dimension are tabulated on Tab.1 . The admissible ground load resistance should not be lower than 1,5 Kg/cm$^2$ and in any case the foundation calculations must be made basing on a local geotechnical study. The maximum distance between tower and wind-bracing anchors (R) is a parameter of the area occupied by the mast and it should not exceed 50 meters.

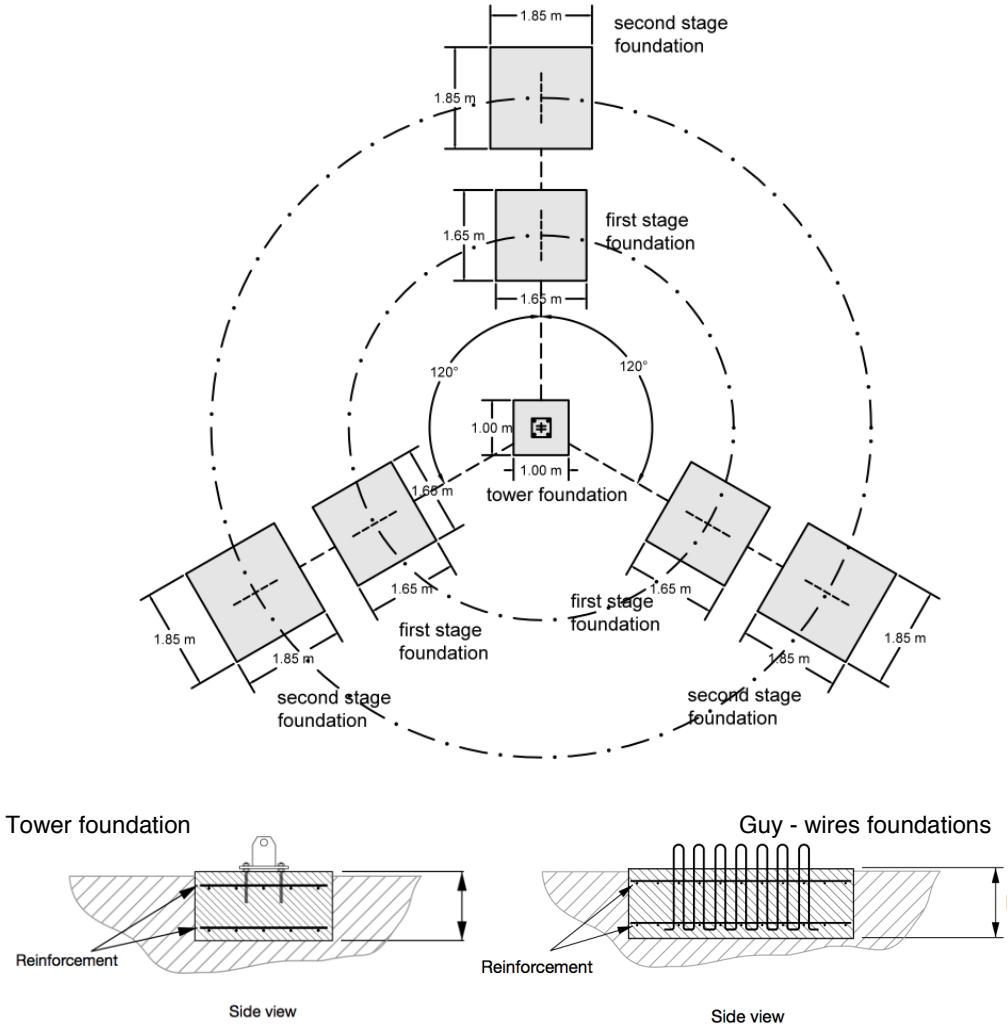


*Fig. 3: typical foundation for meteorological mast with three groups of wind-bracing at 120°. If the one-anchor configuration is chosen, the foundations lying on the external circle (second stage) should not be realised. Figures are not in scale.*

| Foundation | Lenght | Width | Depth |
|---|---|---|---|
| tower bottom | 1,00 m | 1,00 m | 0,45 m |
| 1$^{st}$ stage | 1,65 m | 1,65 m | 0,55 m |
| 2$^{nd}$ stage | 1,85 m | 1,85 m | 0,55 m |

*Tab. 1. Typical dimension of foundation for lattice wind tower. Values are referred to the case shown in Fig. 3.*

The calculations for tower and cables dimensioning should be designed for wind speed exceeding 45 m/s and ice formation up to 1 cm with wind speed of 21 m/s should be taken into account.

## 3. Location

The selection of an adequate location for tower placement is the key to ensuring good quality data and ease of maintenance. The location should allow the placement of meteorological equipment at proper distance from surroundings objects.

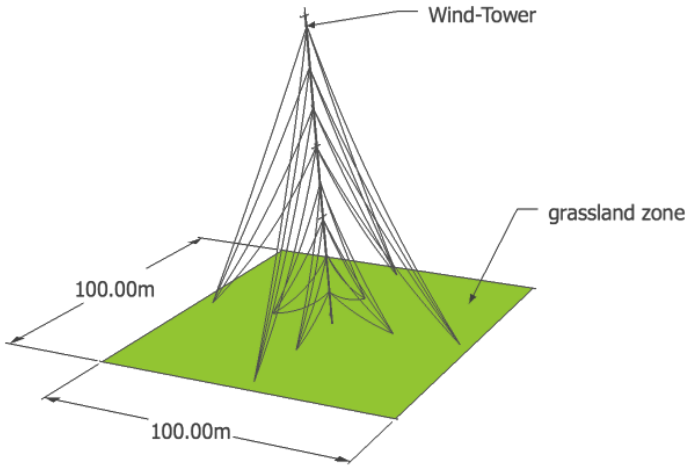


*Fig. 4. A representation of tower, guy-wires and the extensions of restricted area.*

These guidelines are based on open-area criteria and in certain situations encountering them should be difficult, but in any case a square area of 100 meters sideward should be reserved for tower and guy-wires occupancy. This area should not contain any obstacle, tree, cultivation, construction such as houses, cabins, tanks and similar. The 100x100 meters area (MAIN RESERVED AREA) around the tower is available for pasture and rough grazing for ovine. After the tower assembling, the access to this area should be restricted exclusively to maintenance activities and all the tower's structures and cables should be made well visible in order to operate safely. The main features of this restricted zone are summarised in table 2.

Obstacles, different terrain roughness and escarpments may be acceptable beyond the main reserved area; the influence of obstructions, such as buildings and trees, depends on the measured variables.

| Length | Width | Roughness | Terrain | Max. slope | Max. terrain variation from plane | Obstacles |
|---|---|---|---|---|---|---|
| 100 m | 100 m | 0,01 m | Rough | 2 % | < 0,04 (100+h) | none |

*Tab. 2. Main properties of the zone closer to the wind tower (h = tower maximum height)*

The general conditions that minimize the influence of main obstacles and others rough elements are shown in Fig. 5, 6, 7, 8 and summarised in Tab.3. Accurate representative of the site and good data quality strongly depends on the respect of those conditions and every deficiencies should be accurately evaluated prior to any site preparation activities or installation of any equipment.

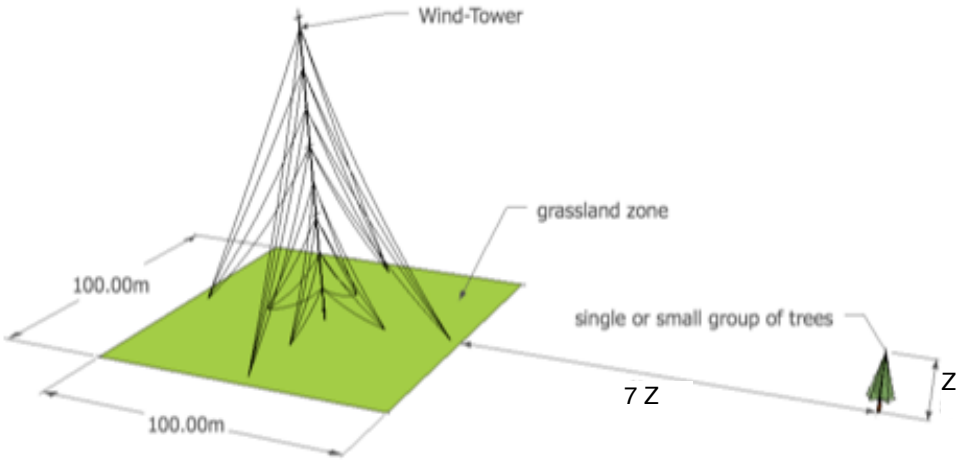


*Fig. 5. Distance from Main Reserved Area to single or small group of trees and similar obstacles.*

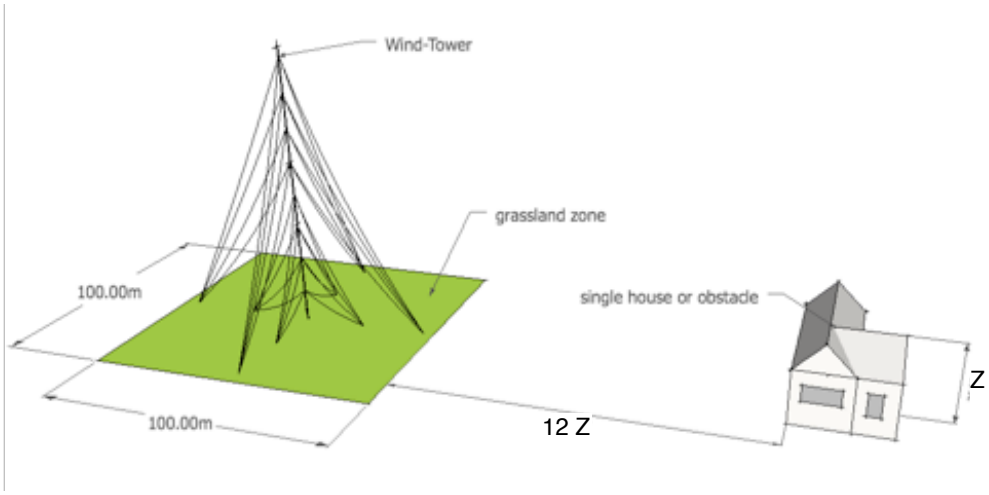


*Fig. 6. Distance from Main Reserved Area*

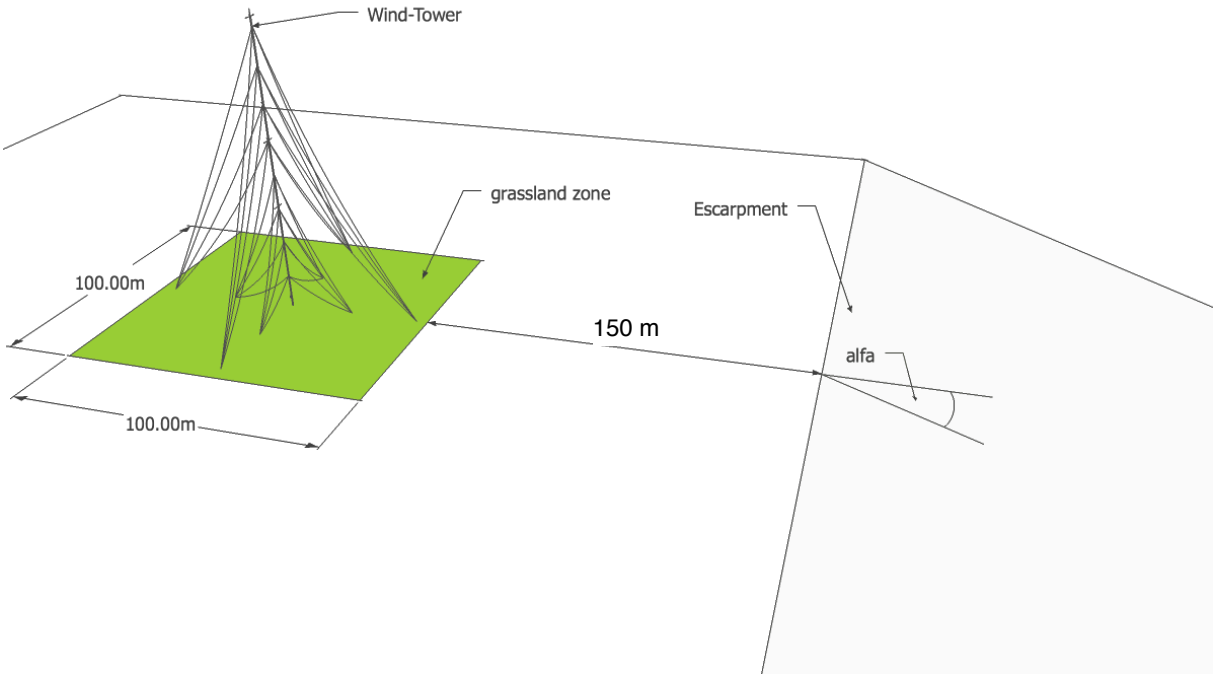


*Fig. 7. Distance from tower's restricted zone for escarpment with slope > 15 % (?)*

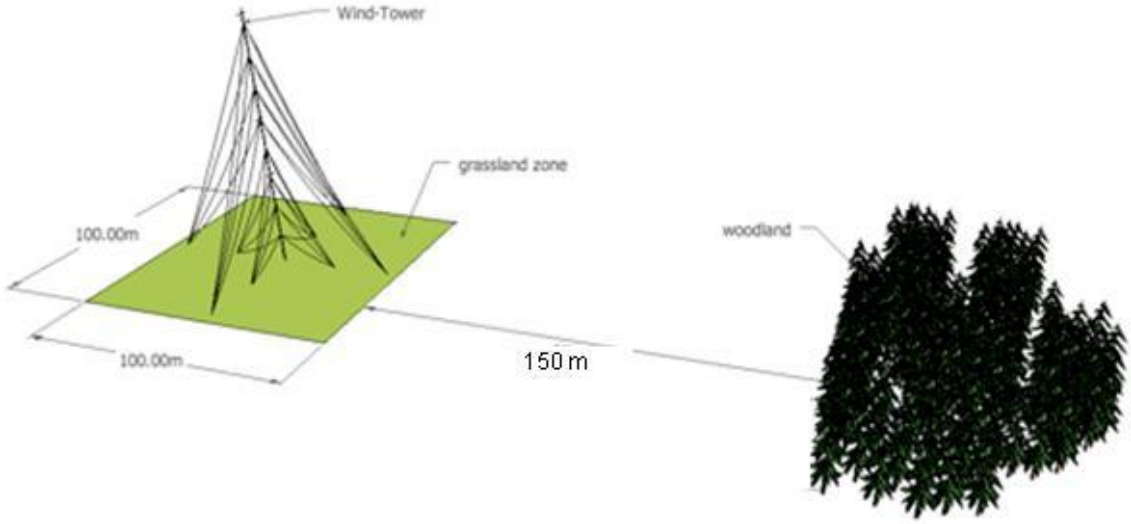


*Fig. 8. Distance from rough terrain (roughness > 0,4)*

| | |
|---|---|
| *Tree Height (Z)* | *Distance = 7 Z* |
| *House height (Z)* | *Distance = 10 Z* |
| *Terrain roughness > 0,4* | *150 m* |
| *Slope > 15 %* | *150 m* |

*Tab. 3. Distance from main obstacles*

## 4. Siting

In order to obtain representative meteorological information a proper site selection is crucial.

As a general rule areas interested of canyoning effect wind, such as ridge line variations, tight valleys, slopes and similar, should be avoided . Separated flow zones as cliffs should be avoided too. The other general rule is to avoid areas affected by strong thermal variations such as locations near seas, lakes, ponds and similar; in these case placing the tower some kilometers inland and aligned with some meteorological coastal stations may be interesting .

Ideal terrain could be lowlands, plains, plateau and they should be rather located between 2 and 5 km from the coast line.

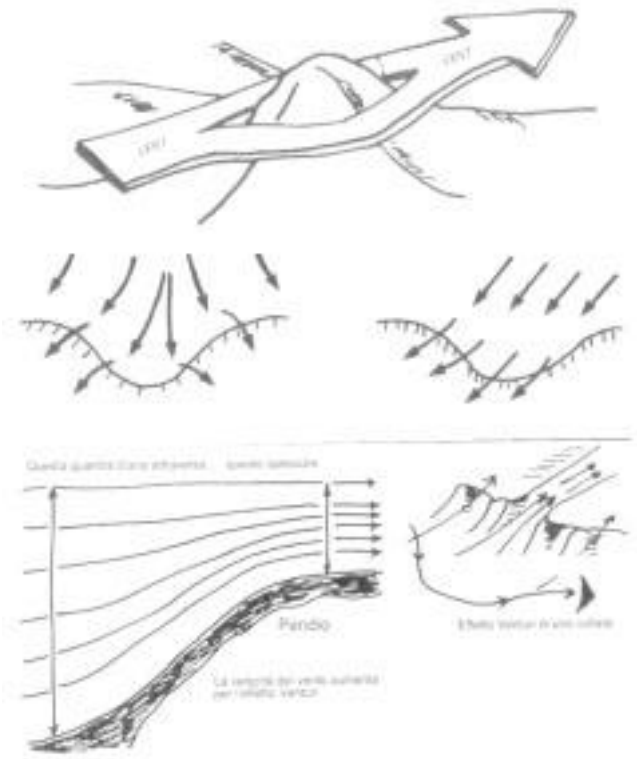

*Fig. 9. Main orographic obstacles*

# POWERED PROJECT

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