



CLIENT: GL – GARRAD HASSAN ITALIA Srl
PROJECT: SAN BASILO Wind Farm, Sardinia, Italy – Technical Due Diligence, Foundations Design Review
DATE: December 10, 2010

FRI-EL GUARDIONARA spa, Bolzano
San Basilio Wind Farm, Sardinia, Italy

TECHNICAL DUE DILIGENCE,
REVIEW OF TURBINE FOUNDATIONS DESIGN

REPORT

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1. INTRODUCTION

1.1 How to read this Due Diligence documentation

This document is the Report. Its salient part is the 'Executive Summary – Recommendations' Section (pages 8 and 9 following), which gives a succinct but comprehensive overview of the due diligence findings. Key issues and relevant evaluation are then displayed in 'Evaluation Tables' (4 no.), which constitute the core work. Comments and results of independent calculations follow each Evaluation Table. Finally, independent calculations and other detailed ancillary information are given in Annexes and Appendices.

1.2 General

This assessment covers the design for the foundations of the wind turbines in the wind farm developed by FRI-EL GUARDIONARA S.p.A. of Bolzano, Italy, in areas of the Municipalities of San Basilio and Siurgus Donigala in the Province of Cagliari, Sardinia. The project comprises No. 27 wind turbines, type VESTAS V52, capacity 850 kW. Hub height is 55 m at all sites but one (site N.10, h=49 m). Please refer to Exhibit 3 at page 7 for turbine characteristics.

1.3 Authors of Proposed Design

The developer is FRI-EL GUARDIONARA S.p.A, Via Portici 16, Bolzano, Italy. The developer's consultants are:

- Prof. Ing. Alessandro De Cesare, Taranto, Italy – Author of the design for the first foundation type and for the wind tower mast (November 2004);
- Dott. Ing. Mario Marongiu, Cagliari - Author of the second (and final) foundation design (May 2009);
- Dott. Geol. Paolo Pili (Geoconsult Srl – no address given) - Author of the Geological Investigation (November 2004);
- Dott. Geol. Gianluca Crotza (no address given) – Author of the Supplement to the Geological Investigation (2009).

1.4 Authors of Review

- Dott. Ing. Luigi Cesare Speranza, Roma (SCANGEA);
- Dott. Ing. Marco Franceschini, Bologna (SCANGEA);
- Prof. Ing. Claudio Scarponi, Roma (UNIVERSITA' 'LA SAPIENZA', ROMA – SCANGEA).

Profiles of authors of review constitute APPENDIX D to this Report.

1.5 Documentation Reviewed

List of documents reviewed constitutes APPENDIX C to this Report.

1.6 Description of Proposed Design

Proposed design is the result of two subsequent stages. In 2004 Dott. Ing. A. De Cesare envisaged for all turbine sites a shallow foundation consisting of a square slab (dimensions: 12,10m x 12,10m x 1,10m) supporting a parallelepiped plinth (dimensions: 4,50m x 4,50m x 1,00m) located at its centre. Calculations were carried out by the Designer with the 'Admissible Tensions Method', which was the legal standard in Italy at the time (2004). Five foundations were built accordingly (turbine sites No. 3, 7, 10, 19 and 32), but then works were suspended. Activities resumed in 2008. The foundation design was modified by Dott. Ing. M. Marongiu to comply with the new legal standards (i.e. the Italian NTC-2008 and the Euro-Codes). As a result, a truncated pyramidal shape was adopted for the new plinths. The existing ones were modified by adding ribs (4 no.) on top of the parallelepiped slabs. Connection between the ribs and the slabs were designed and realized with Hilti chemical resin anchorages. Works were completed in 2010. As a result, two different foundation plinths are now existing in the wind farm.

- Type A) Initial Eng. De Cesare design modified by Eng. Marongiu ;
- Type B) New design by Eng. Marongiu.



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Please refer to drawings in Exhibits 1 and Exhibit 2 in following pages.

1.7 Method of Review - Guidelines

The aim of this technical due diligence review is two-fold:

- a) to verify the viability of the proposed foundation structures via independent calculations complying with international standards of calculation (Euro-Codes, IEC 61400-1 and Italian NTC-2008);
- b) to evaluate the calculations and ancillary documentation of the proposed design so as to assess their compliance with current Italian standards. This in order to foresee potential bottlenecks in the path of approvals from Italian Authorities (Regione, Genio Civile etc.) and ensure that an adequate maintenance plan is drawn up and enforced.

As construction works in this case are completed, the second purpose may appear less important, but it is not. Firstly, for the sake of good order, it is good practice that omissions and flaws in the design documentation be addressed and dealt with. Secondly, as said, it is of paramount importance (and the law provides for it) that an adequate maintenance plan exist and be enforced.

Review criteria have been derived from previous experiences of Garrad Hassan, integrated with specific topics which are sensitive for the Italian codes (e.g.: seismic actions, etc.).

1.8 Method of Review – Evaluation Tables

Evaluation of the proposed design is carried out by filling in the following Evaluation Tables:

- **Evaluation Table 1** – GEOLOGICAL INVESTIGATION;
- **Evaluation Table 2** – TURBINE LOADS;
- **Evaluation Table 3** – Type A foundation (shallow) STABILITY;
- **Evaluation Table 4** – Type A foundation (shallow) STRUCTURAL;

1.9 Method of Review – Checks in Evaluation Tables

In compliance with points a) and b) of preceding Paragraph 1.7 (Aim of this review), checks in Evaluation Tables are given separately to structure soundness (evaluated with independent calculations) and design documentation quality.

Checks are given by crossing in the applicable cell in the criteria columns. Colour of crosses in the third column ('Insufficient or Omitted') can be either black or red. Black is given when the issue, though rated insufficiently dealt with, or omitted, is not deemed crucial. Red is given for issues which are deemed to be crucial.