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CLOSE OUT ENGINEERING GEOLOGICAL REPORT FOR TURBINE POSITIONS T1 TO T46,
SERE WINDFARM, KOEKENAAP.

1. INTRODUCTION

This report constitutes a final summary of the geological and geotechnical data gathered prior to and during the construction of turbine positions T1 to T46, for input into the foundation design analysis and construction approval of the forty six wind turbines built on the site.

2. PREMISES UPON WHICH INVESTIGATIONS WERE BASED

The method of foundation analysis adopted, utilized a finite element analysis with input parameters of ground shear wave and pressure wave velocities (V_s and V_p), in accordance with the methods of inter-alia, Vucetic, Dobry and Alpan and as detailed in the relevant design report of ABT, the foundation design engineers. Based on the typical parameters for the site, a model depth of 20m was adjudged as being adequate in terms of soil stiffness or deformation (settlement) and of the order of half of that in terms of soil strength (bearing capacity).

The investigations were consequently primarily directed towards determining these input parameters at each turbine position by conducting seismic profiling and probing. The confidence limits of the results were enhanced by considering sample geological profiles obtained from borehole drilling, sampling and in-situ testing in close proximity to, or at each turbine position and uniformly distributed across the whole site.

The design analysis yielded a single foundation configuration designed to cater for the range of soil conditions present on the site. The investigations were then directed towards confirming that the range of soil parameters designed for, were not transgressed at any one turbine position. This included the consistency or density of the founding surface as affected by excavation and subsequent compaction, prior to the casting of the concrete base.

The electrical earthing design also required a measure of the ground resistivity.

3. INVESTIGATIONS AND TESTS UNDERTAKEN

An initial geotechnical report covering the area for a different layout of forty six turbines, was prepared by BKS Palace Consortium in 2010 and was made available and is appended as appendix B.

Investigative methods employed included:

- Percussion drilling
- Rotary drilling
- Standard Penetration Tests (SPT's)

- Dynamic Probe Super Heavy (DPSH) tests
- Plate Load tests
- Excavation of test pits
- Geophysical Electrical Resistivity survey
- Geophysical Seismic Refraction survey
- Laboratory tests
- Seismic Hazard assessment.

As the positions of these turbines did not coincide with those of the current layout, further seismic profiling, DPSH testing and electrical resistivity profiling was carried out at each of the current positions. After excavation and foundation surface compaction, Light Dynamic Probes (DPLs or DCPs) and Troxler nuclear density tests were conducted. Where prior borehole drilling had not taken place within close proximity to any of the new positions, new rotary cored boreholes with SPTs were drilled at the new positions thus extending the extent of the known general geological profile.

This added the following to the above list:

- Light Dynamic Probes (DPLs or DCPs)
- Nuclear Density tests (Troxler)
- Compaction control tests (MOD. AASHTO density)

Ultimately the construction of the turbine foundations made use of at least, the following numbers of relevant tests:-

	BKS	Recent	Total
Percussion drilled boreholes	33	0	33
Rotary drilled boreholes	29	24	53
Standard Penetration Tests (SPT's)	407	216	623
Dynamic Probe Super Heavy (DPSH) tests	46	174	220
Plate Load tests	11	0	11
Excavation of test pits	6	0	6
Geophysical Electrical Resistivity profiles	49	28	77
Geophysical Seismic Refraction profiles	48	45	93
Laboratory foundation indicator tests	10	9	19
Light Dynamic Probes (DPLs or DCPs)	0	1032	1032
Nuclear Density tests (Troxler)	0	516	516
Compaction control tests (MOD. AASHTO density)	4	43	47

The distributions of the various borehole and test positions across the site are shown on the appended layout drawing as appendix A. To avoid confusion, the new positions are referenced with the prefix T and the old positions of the BKS report with the prefix TWG.

A description of the methodology of the seismic and resistivity surveys conducted in the recent phase of testing is contained in the reports prepared by Engineering and Exploration Geophysical Services appended as appendix C.

4. RESULTS OF INVESTIGATIONS AND TESTS

The description of the site and its geological setting are adequately described in the appended BKS report and the reader is referred thereto; similarly for the seismic hazard parameters.

A short report summarizing the groundwater situation with regards to the water table affecting the foundations is appended as appendix D.

As construction commenced prior to the geotechnical and geological investigation being completed for the whole project, reports summarizing conditions for each of the seven strings of turbines were prepared ahead of the construction of each of the strings as the information became available. The seven strings resulted in seven individual reports covering the turbine positions contained in each string.

The strings in order of construction contained the following turbine positions:-

String 1	Positions T7 to T13
String 2	Positions T14 to T20
String 3	Positions T21 to T27
String 4	Positions T35 to T41
String 5	Positions T28 to T34
String 6	Positions T35 to T41
String 7	Positions T1 to T6

These seven individual reports are appended as appendix E and the reader is referred to each of the relevant detailed reports for information relating to any particular turbine or string of turbines. The borehole logs and photographs, SPT, DPSH, seismic and resistivity profiles and lab test results referred to in each report are included as appendices to each.

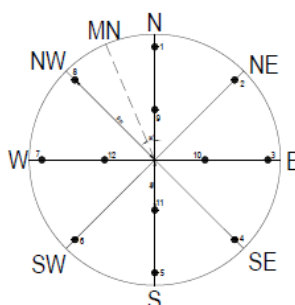
5. ACCEPTANCE OF FIELD TESTS DONE DURING CONSTRUCTION

For each turbine, after excavation to the founding levels listed below and except in the few cases where rock was encountered, twelve DCP tests were conducted down to 1,5 m or refusal at the positions indicated on the sketch plan below. These were repeated at the same positions after compaction and Troxler densities determined at a depth of 0,3 m in terms of a compaction control test carried out on a soil sample taken at founding level. This yielded twelve DCPs before compaction and twelve after compaction plus twelve relative densities after compaction.

For each individual turbine position, these results were assessed in conjunction with the earlier DPSH tests, seismic profiles and SPT tests below founding level to assess whether further ground improvement was required to attain the parameters assumed for design. These assessments along with their relevant test results are individually appended under appendix F. Barring a few cases where extra compaction or some soil replacement was called for and retesting done afterwards, no further ground improvement treatment was deemed necessary.

SERE WIND FARM
DCP AND TROXLER POSITIONS

TURBINE NO.



FOUNDING LEVELS AND EXCAVATION DEPTHS					
Posn.	Y Lo19	X Lo19	NGL.	Founding level	Depth of Excavation below NGL
T1	81 512.860	3 485 984.544	99.481	96.400	3.081
T2	81 875.143	3 485 873.486	92.840	90.249	2.591
T3	82 264.789	3 485 695.418	84.901	82.191	2.710
T4	82 674.233	3 485 594.472	82.037	79.172	2.865
T5	83 058.743	3 485 321.020	82.108	79.656	2.452
T6	83 448.935	3 485 172.935	84.034	81.552	2.482
T7	83 175.350	3 487 601.283	71.786	69.734	2.052
T8	83 601.906	3 487 528.510	77.823	75.676	2.147
T9	84 264.720	3 487 473.416	72.874	70.800	2.074
T10	84 646.183	3 487 285.498	67.582	65.410	2.172
T11	85 118.445	3 487 141.143	66.917	65.016	1.901
T12	85 515.342	3 486 978.927	73.279	70.959	2.320
T13	85 913.845	3 486 793.477	74.175	71.992	2.183
T14	86 482.068	3 487 143.000	84.795	81.950	2.845
T15	86 875.435	3 486 785.915	86.364	83.905	2.459
T16	87 230.692	3 487 079.342	99.049	96.588	2.461
T17	87 637.743	3 487 471.793	101.177	98.681	2.496
T18	87 443.342	3 487 775.258	97.829	95.537	2.292
T19	86 870.989	3 487 801.708	104.539	101.739	2.800
T20	86 546.637	3 487 941.595	92.539	90.345	2.194
T21	86 152.358	3 488 248.713	76.662	74.238	2.424
T22	85 454.613	3 488 361.432	58.685	56.368	2.317
T23	86 956.428	3 488 483.953	86.849	84.522	2.327
T24	86 712.972	3 488 838.302	75.429	73.031	2.398
T25	86 421.372	3 489 293.504	63.220	60.829	2.391
T26	86 129.773	3 489 748.706	58.090	55.666	2.424
T27	85 928.324	3 490 049.305	65.774	63.050	2.724
T28	85 691.919	3 490 406.527	67.398	64.939	2.459
T29	85 476.716	3 490 720.375	71.871	69.461	2.41
T30	85 238.423	3 491 083.632	72.894	70.289	2.605
T31	84 959.729	3 491 369.650	65.313	62.849	2.464
T32	84 718.102	3 491 823.945	56.440	53.905	2.535
T33	84 424.679	3 492 179.215	51.169	48.689	2.48
T34	84 081.286	3 492 535.400	52.959	50.322	2.637
T35	83 824.372	3 492 918.997	71.156	68.649	2.507
T36	83 598.756	3 493 210.047	83.399	80.529	2.87
T37	83 399.070	3 493 497.623	96.008	93.260	2.748
T38	83 155.618	3 493 851.984	114.466	112.009	2.457
T39	82 992.914	3 493 155.145	98.019	95.116	2.903
T40	83 130.945	3 492 502.793	81.254	78.786	2.468
T41	82 721.136	3 491 960.432	73.398	70.783	2.615
T42	83 258.932	3 491 300.771	68.938	66.137	2.801
T43	83 609.634	3 491 344.346	66.359	63.987	2.372
T44	84 208.358	3 491 283.414	63.947	61.382	2.565
T45	84 450.900	3 490 879.088	67.387	64.678	2.709
T46	84 793.382	3 490 472.937	71.264	68.483	2.781

6. EVALUATION OF RESULTS

The data obtained from all of the testing which was well distributed over the site, yielded a clear understanding of the distribution of geological profiles which enabled identification of the worst likely profile for which the single foundation type needed to be designed for.

Tests conducted at each position confirmed that the conditions at each position were not sub-standard when compared to the conditions designed for, and in most cases, were far better.

In a few isolated cases, the density testing after excavation and compaction identified the need for further compaction or some soil replacement before retesting indicated adequate compaction.

In all cases, the final test results at each position and the area surrounding it, were assessed and approved by the geotechnical engineer and the foundation design engineer prior to the casting of the base.

7. CONCLUSION

It is concluded that all of the testing done, both before and during construction, served to confirm that the conditions in terms of soil or rock parameters below each foundation, were better or at least equal to, those utilized in the foundation design analysis.



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