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ENERGY & INDUSTRY DIVISION

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Risk Mitigation & Life Extension

Civil Inspections for in-service Wind Farms

ENERGY & INDUSTRY DIVISION

Civil Inspections for Wind Farm

Risk Mitigation & Life Extension

- Mechanical Elasticity is a property where an element is able to experiment reversible deformations when subjected to external forces and regain to their original shape when those forces are eliminated.

- A Wind Tower is not a static elements, therefore:
  - Two different elasticity behaviors are taking place in the tower base, where concrete and metal meet.
  - Separate tower horizontal planes: Base, middle tower or nacelle, have different displacements and deformations tolerance structural performance, however all have been designed to be centered on the same vertical axis.

Civil Inspections for Wind Farm

Risk Mitigation & Life Extension

- Having a structure under constant stress causes exponential side effects in the long term operation.
- Low cost predictive & preventive inspections help to take better business decision anticipating and planning proper corrective or maintenance activities to:
  - Improve unavailability losses due vibrations shutdowns.
  - Life extension of the wind tower after amortization periods.
  - or even prevent from collapsing.

Tower Foundation Movement Measurements

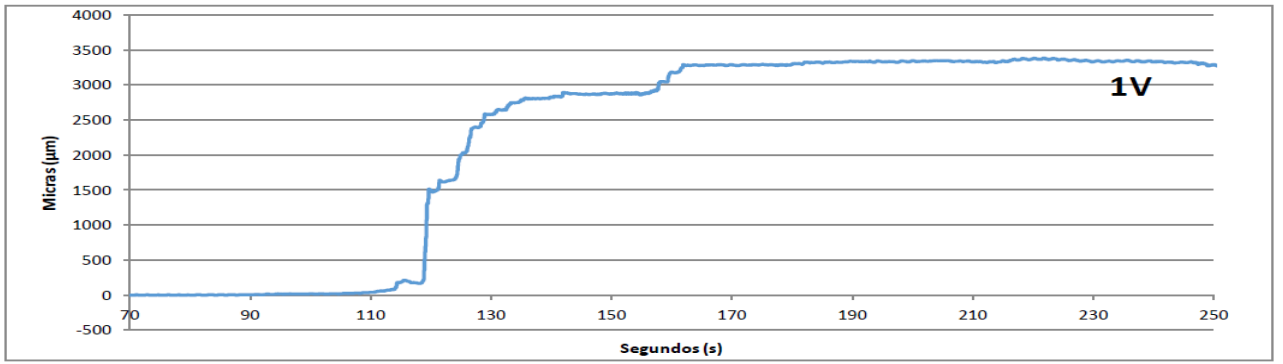
- The dynamic forces in the base generate foundation micro cracks due the differences elasticity, no matter if grouting or anchor bolt.

- Water leaks in combination with the vibration forces generate internal high pressure in those cracks which accelerate the process but also generates erosion, which increase the vibrations forces, which generates more cracking, which generates more erosion, which generates more vibrations, … It is an exponential phenomenon.

- After 5 or 10 years operation, it is high recommended to determinate foundation health

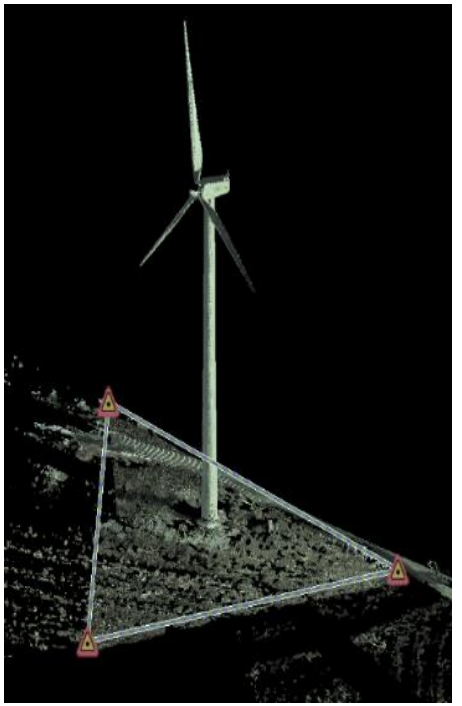
Tower Foundation Movement Measurements

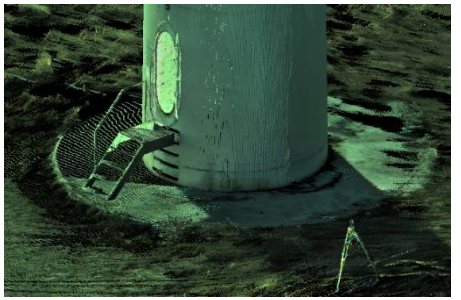
- ✓ Linear strain control sensors to measure vertical & horizontal movements at 4 points: Wind direction & perpendicular.
- ✓ Readings at normal operation and during the start-up.
- ✓ Reporting magnitudes of displacement to determinate the need of rehabilitation treatments periods.



Wind tower Verticality & Horizontal Planes

- Verticality measurements are very useful:
  - In aged tower deformation during long term standard operation, after 5 o 10 years.
  - After suffer a big shock like a strong storm or a blade impact (real case).
- All that can cause important deviations in the vertical axis reference over several tower planes and affecting foundation seating differential.
- Becoming in an abnormal behavior of the tower, stressing the structure, generating extra vibrations and causing un expected fails or amplified others in the foundation, in the tower itself in the gear-box or on the alignment of the shaft.

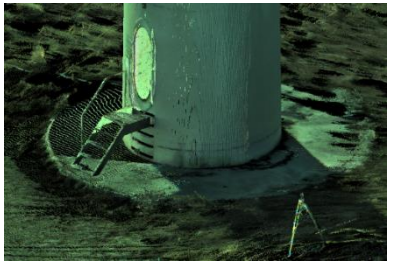




Wind tower Verticality & Horizontal Planes

- ✓ Using a total station with several references points
- ✓ 100 readings per second measuring different horizontal planes: Bottom, middle & top
- ✓ Point cloud data processing to determinate flatness, inclination and verticality over the circumferences planes.

⊕ Job can be done also by a Laser Scan to obtain the 3D point cloud, but the accuracy will not be the same. However could help to locate deformations.



ACTA DE COMPROBACIÓN DE VERTICALIDAD DE UN AEROGENERADOR

INSTALACIÓN:	PARQUE EÓLICO	FECHA:	04/12/2019
		Nº SERIE:	737470
INSTRUMENTO:	LEICA TCRP1202 R300	FECHA CALIBRACIÓN:	07.05.2019

AEROGENERADOR A09 EN REPOSO

P.E.

PARÁMETROS DE MEDIDA:

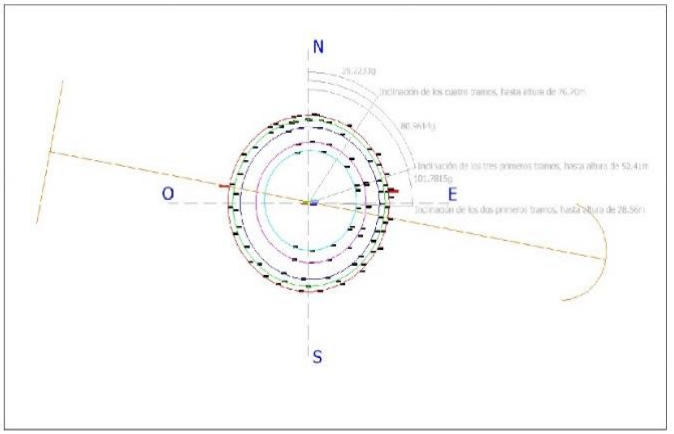
HORA DE MEDICIÓN:	10:00-13:00
VELOCIDAD MEDIA DEL VIENTO:	1.5 m/s
AZIMUTAL DEL VIENTO:	
TEMPERATURA MEDIA:	4ºC

DESVIACIÓN VERTICAL

ESTADO	ANGULAR (g)	EXCENTRICIDAD (m)
EN REPOSO		
	0.0658	0.01
	0.0716	0.03
	0.0791	0.06
	0.0654	0.08

DESVIACIÓN HORIZONTAL:

ANILLOS	TRAMOS (m)	DIÁMETRO (m)	DESNIVEL (mm)	ANGULAR (g)
ANILLO 1	0.49	4.04	1.5	0.0233
ANILLO 2	11.10	3.81	3.0	0.0508
ANILLO 3	16.97	3.49	2.7	0.0487
ANILLO 4	23.85	2.77	1.1	0.0242
ANILLO 5	24.29	2.30	-	-
ALTURA:	76.70			



Civil Inspections for Wind Farm

Risk Mitigation & Life Extension

- Easy, Faster and cheaper test HELP:
  - To avoid unavailability losses
  - To life extension after the amortization period
  - To prevent from collapsing due aging

Less than 300 € per tower (**)

(**) In normal conditions 3 to 5 towers can be tested per day

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