Study Committee B2

Overhead Lines

10539_2022

Full Scale Test of the 380 KV double circuit pylons (Wintrack type III)

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Motivation

- Wintrack innovative towers provides a reduction in the magnetic field, austere shape and flexibility in the multi-voltage lines. A Wintrack tower consists of two steel poles, to which the high-voltage conductors are connected. The tower is low-maintenance due to lower number of bolts and smoother body.
- The aim of the full-scale test was:
    - To approve the maintainability and manufacturability of the design towers and details.
    - To investigate the global structural behavior and the structural integrity of the design towers
    - To investigate the load capacity of all critical parts and components.

Approach

- In this full-scale test, two representative four-circuit Wintrack towers were tested :
    - The heaviest common tension tower (HM400)
    - The common suspension tower (S350U) of which the most are build.
- The stress and displacement in cross arms, entrance door and the bolted connections were measured and simulated using FE analysis.

Objects of investigation

- TenneT asset management planned further full-scale test on the representative tower types to validate the design and simulation results with the experimental tests.
- The criteria that the towers and components should fulfil during the tests are mainly related to the permanent deformations and opening of the bolted flange connected under ULS load levels. Moreover, the tower and the components displacement under EDS and SLS load cases should meet the requirements and the base plate and flange should not lose any pressure contact.

Experimental setup & test procedure

- A training location of TenneT's management & maintenance organization at Geertruidenberg was chosen as the full-scale test location.

- The two suspension and tension towers are located at both sides. When one of the towers is being tested, the other one works as the anchor of the tensioned pulling wires. Additionally, an auxiliary tower (suspension tower type) has been placed in between as an "intermediate" support point to facilitate the horizontal loads on the testing towers.
- In this full-scale test, the tower body and the cross arms have been loaded in a stepwise manner, the loads are increase to 25% of the load level, then are increased to 50%, 75%, 90% and 100% respectively and it is maintained constant for 5.

Discussion

- The stress levels have been measured and simulated in the cross arms, flanges, bolted connection and the tower base around the door frame.
- The simulation and the experimental tests were in a strong agreement. In most of the cases, the deviation was less than 5%, however, the deviation was higher in the locations with very low stress level.
- The tower's deflection and displacement and the cross arms displacement were in agreement with simulation within 5% deviation.
- Tower flanges and cross arms' bolted connections act as were simulated and opening was not exceeding the design limits.

Conclusion

From this study, it can be concluded that the Wintrack towers are adequately designed to resist high mechanical loads and fulfils TenneT requirements for permanent deformations and bolted connection opening. The structural integrity between the whole body and the components can be validated.

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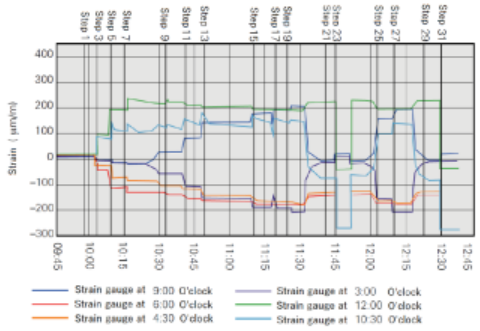
Continued

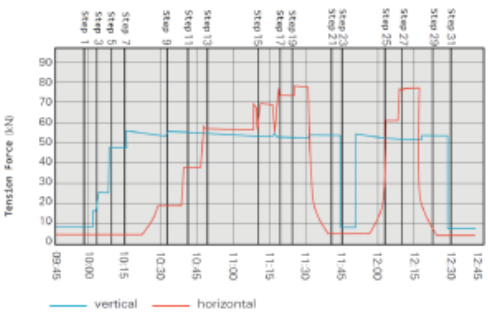
Measurement

- One of the challenges was instrumentation of the tower and the components as it many cases, it was supposed to measured many parameters at the same time.

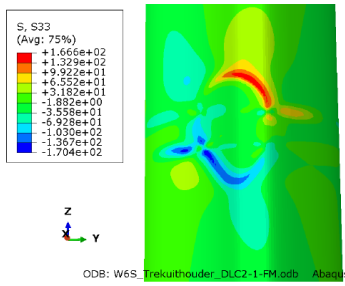
Result on cross arms

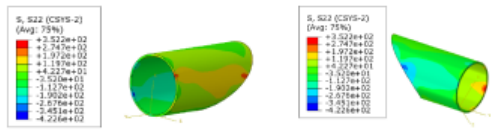
- Two figures below show the measured applied force and the measured strain realized at the measured points.





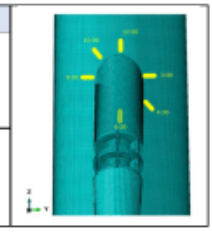
- The same connection has been simulated using the applied forces in Abaqus FE software.





- Table below shows the comparison between the measured and simulated points. The areas with lower stress level led to higher deviation but generally in acceptable deviation for critical values.

	location	Measurement [MPa]	Simulation [MPa]	Deviation [%]
Strain	12	61	60	2
	3	58.2	60	-3
	04:30	50.5	55	-9
	6	52.1	54	-23
	9	53	56	-28
	10:30	47.4	44	7
Tension	12	8	11	-38
	3	137.8	140	1.5
	04:30	243.5	246	1
	6	68	69	1
	9	157	166	-5
	10:30	28	32	-14



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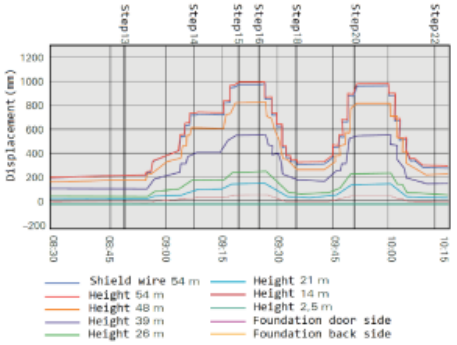
Continued

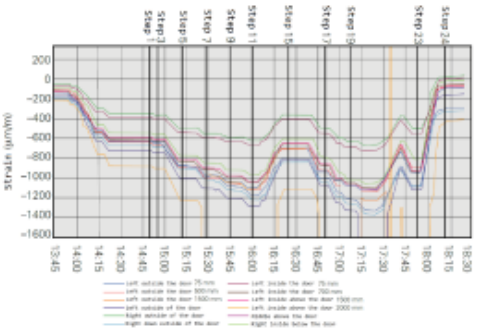
Results on tower body

- The deflection curvature, deformation of the tower identifies the influence of the foundation in the deformation. This validates the stiffness values used in the calculation models.
- The measure displacement agrees with mean calculated displacement using FE models.



Tower door behavior

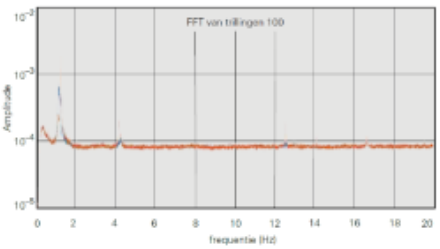
- The door frame and the area around that should resist the loads in particular the buckling.
- Measured and simulated stress level around the door frame shows adequate stress level under ultimate limit state loads. This approves that the door frame design is appropriate.



	Measured stress [MPa]	Measured stress (axial) [MPa]
Outside above the door on the left	294	280
Inside above the door in the middle	245	224
Outside below the door on the right	283	280

Dynamic behavior of tower

- The vibration were measured using accelerometer to determine the natural frequencies of the towers. It is important to avoid all aeolian vibration and vortex shedding on the tower.
- The measured natural frequencies were compared to the mode shapes extracted from finite element model.
- The first two natural frequencies from measurement and calculation are in strong agreement.

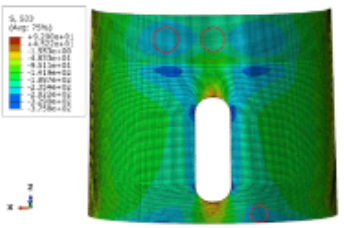


Mode	Measured Eigenfrequency [Hz]	Calculated Eigenfrequency [Hz]
1	1.17	1.00
2	4.12	3.58
3	12.56	8

Conclusion

From the performed tests it can be concluded that:

- The Wintrack towers are adequately designed to resist high mechanical loads and fulfils TenneT requirements for permanent deformations and bolted connection opening.
- The structural integrity between the whole body and the components can be validated.
- The manufacturability and the maintenance ability of the towers are proven and approved.
- From the obtained results, it can be concluded that structural integrity and resistance of other tower types and families can be also approved.



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