Scottish & Southern Electricity Networks

SHE Transmission

New Suite of Transmission Structures: NeSTS (SSEN003)

Outputs of Type Testing

May 2020

Contents and Overview

Contents

Overview of NeSTS

Scottish Hydro Electric Transmission plc (SHE Transmission) is developing a New Suite of Transmission Structures (NeSTS), which are planned to be deployed on the transmission network.

Overhead lines (OHLs) built using transmission structures are the most visible element of the transmission network. The impact OHLs have on the environment can cause stakeholders concern.

The only available alternative to the steel lattice structures traditionally used in OHL construction is the T-Pylon. Developed by National Grid, the T-Pylon reduces the visual impact of OHLs but may be unsuited to areas with challenging terrain and propensity for severe weather events.

Establishing new infrastructure in these areas is essential to connect renewable generation, so there is a need for a new type of structure to address stakeholder concern.

The NeSTS project is developing innovative designs for OHL structures based on new technologies and techniques. The new suite of structures will then be deployed on the transmission network.

The NeSTS Project seeks to prove the following benefits:

- Improved OHL environmental performance by lowering visual and construction impacts; and
- Lower OHL whole life asset costs via reduced land, construction, maintenance and outage requirements.

Introduction

The Project is developing the following suites of structures;

- NeSTS 132kV Single Circuit
- NeSTS 132kV Double Circuit; and
- NeSTS 275kV Double Circuit

These have developed in response to changing network requirements for OHLs which are planned to be constructed using NeSTS, and are at correspondingly different stages of evolution.

The first of these to be type approved for deployment on the network is the 132kV Single Circuit suite.

This report summarises the results of its type testing and the conclusions drawn regarding its design.

Its submission fulfils the requirements of the Project's sixth Successful Delivery Reward Criterion (SDRC), Completion of Type Testing.

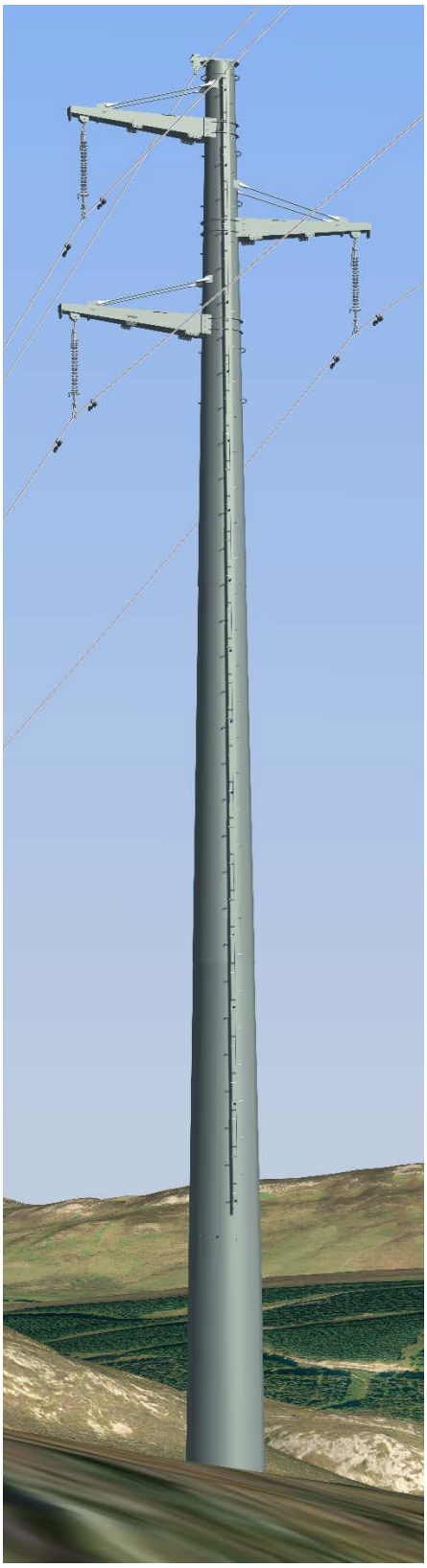


Figure 1: A NeSTS 132kV Single Circuit D2 Support modelled on the Aberarder windfarm project

Outputs of Type Testing

Test Specifications

The NeSTS 132kV Single Circuit suite of supports has been designed in response to its Preliminary Technical Specification which is shown in Appendix 1.

A corresponding NeSTS 132kV Preliminary Test Specification, shown in Appendix 2, has been developed to enable full scale testing of structures to establish whether their design meets the requirements of their Preliminary Technical Specification.

SHE Transmission elected to test a S2 standard height (STD) suspension structure utilising a spigot foundation connected to a raft foundation, a S30 STD structure utilising a flanged foundation connection, and a short section of an S30 pole housing one cross arm.

While testing has been specified in accordance with BS EN 60652:2004 and BS EN 61773:1997, the Project has further tightened the acceptance criteria regarding permanent local deformations following the full scale cross arm and pole section testing reported in SSEN003 NeSTS Project Progress Report June 2019.

Instrumentation of the test structures with strain gauges has been specified to enable measurement of deformation beyond the capabilities of visual inspection and displacement measurement.

The intention is to produce structures which do not deform significantly during full scale testing, and whose deformation can be predicted using finite element analysis tools.

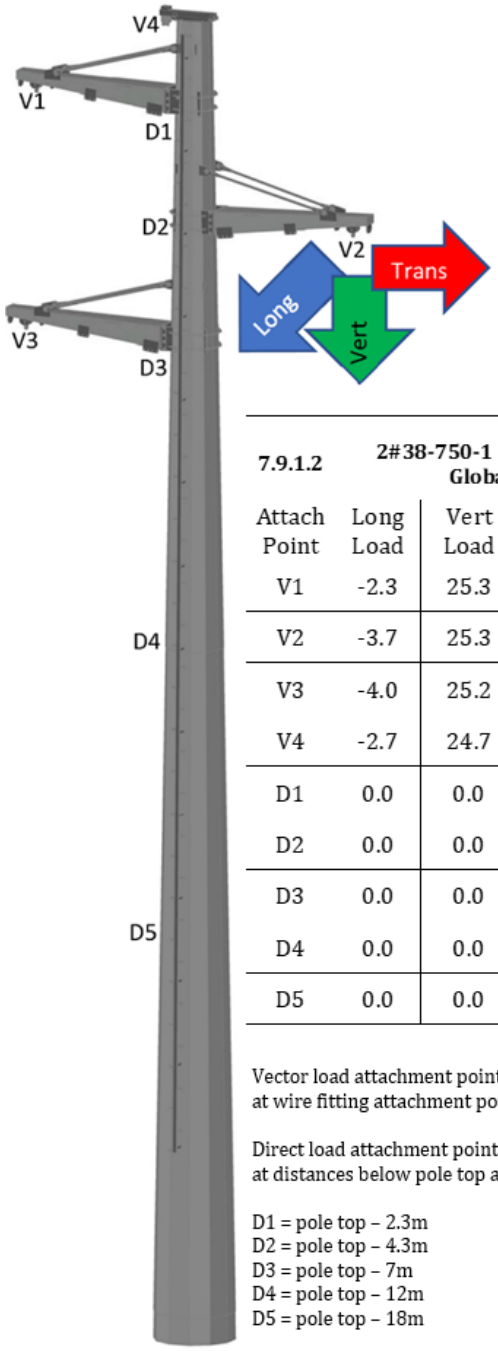
As potential manufacturers of the supports employ different manufacturing process which require differences in detail design features, a separate testing exercise is required for each manufacturer's products.

Different testing stations use different methodologies to conduct full scale testing.

It therefore follows that each combination of manufacturer and test station are required to produce a unique test specification and report in response to the NeSTS specifications.

This report summarises the Project's first of these, where the NeSTS test structures were designed, manufactured, and tested by Valmont Structures.

The test engineering was conducted by Krabbenhoft & Ingolfsson on behalf of Valmont SM and their specification for the tests is shown in Appendix 3.



7.9.1.2	2#38-750-1 3a 180,C Global		
Attach Point	Long Load	Vert Load	Trans Load
V1	-2.3	25.3	35.7
V2	-3.7	25.3	34.9
V3	-4.0	25.2	34.0
V4	-2.7	24.7	33.6
D1	0.0	0.0	5.7
D2	0.0	0.0	4.5
D3	0.0	0.0	7.9
D4	0.0	0.0	12.1
D5	0.0	0.0	22.5

Vector load attachment points shown at wire fitting attachment points.

Direct load attachment points defined at distances below pole top as follows;

D1 = pole top – 2.3m
D2 = pole top – 4.3m
D3 = pole top – 7m
D4 = pole top – 12m
D5 = pole top – 18m

Foundation Reactions – all forces in kN, all moments in KN-m							
Long Force	Vert Force	Trans Force	Shear Force	Long Moment	Vert Moment	Trans Moment	Bending Moment
13	-225	-193	193	-269	-10	3709	3719

Figure 2: S2 STD Load case 7.9.1.2 excerpted from NeSTS 132kV SC Preliminary Test Specification

Outputs of Type Testing

Results of Testing

The testing detailed in this specification was conducted in Rodekro, Denmark in March 2020 safely and successfully.

The results are presented in detail in Appendix 4.

The structures passed the tests satisfactorily, including consideration of permanent deformation at the cross arm connections, and behaviour under overload.

These results validate the Project's PLS-POLE and ANSYS design toolset, Valmont's manufacturing process, and the NeSTS 132kV Preliminary Technical Specification, which will consequently be presented for review by the Overhead Line Panel at the Energy Networks Association.

Video summaries of the tests are available on the Project website (www.NeSTSproject.com).

Figure 3: NeSTS 132kV S30 STD and S2 STD Test Structures

Outputs of Type Testing

Learning from Testing;

Foundation – Spigot Connection

The S2 STD test structure was connected to its raft foundation via a reinforced concrete spigot. The design of the spigot and foundation is detailed in Appendix 5.

The Project has successfully prototyped this type of connection in order to demonstrate its constructability to main contractors. Video footage of this, published in a presentation made to the LCNI conference on 30 October 2019, is available on the Project website (www.NeSTSproject.com).

The test reported herein validates its fitness for purpose, although has revealed a potential issue when slip jointing on to it.

Spigot - Pole Connection

The slip joint between the spigot and the pole moved slightly during the S2 STD combined wind and ice load case test.

This may indicate that the well reported practice of making slip joints in tubular steel structures by applying full design load to the joint is not adequate when one of the tubes being jointed is full of reinforced concrete.

The Project will further investigate the specification of slip joint making forces for application to spigot foundation connections.

Measurement of Joint Movements

More precise measurement of any joint movements is desirable, either at slip or bolted joints in order to understand the components of measured deflections.

This will be added as a requirement for future NeSTS full scale testing.

Cross Arm Test Equivalency

The Project is investigating whether testing of short pole sections housing a single cross arm and its connection could be used as proxy for full scale structure testing in order to reduce costs and design validation timescales for NeSTS structures in future.

The differences in strain measured on the cross arm structure compared to that measured on the full structures have illustrated that the anticipated equivalency has not been demonstrated by this test programme.

The Project will investigate the reasons for this and report further on the potential for using cross arm testing and Finite Element Analysis as proxy for full structure testing.

This page is intentionally blank

SSEN003 NeSTS: Outputs of Type Testing Rev 1.0 – May 2020