Deadwater Fell Test Site (EA Technology)

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Abstract:-EA Technology has a severe weather test site at Deadwater Fell on the Scotland/England border in the UK. The site has been used to test icemeters and validate icing models under the COST727 programme. This site comprises a 200m test span plus a platform for icing monitors. It is equipped with meteorological instruments and video coverage as well as load cells and is fully described here. The tensions of various conductors are monitored for ice loads by the load cells as well as time lapse video cameras. The data on modelling and icemeter validation from the site is described in other papers at this workshop.

I. Background

EA Technology has operated several severe weather test sites throughout the UK since 1988 to encompass a full range of weather conditions: gales, pollution, wet and dry snow, hard and soft rime ice and glaze icing (freezing rain). The sites are situated in exposed locations at heights between 170m (Susseter Hill in Shetland (an island off the north coast of Scotland)) and 750m (Green Lowther in South West Scotland). Overhead line conductors are erected in test spans of between 90m and 200m. These two sites have since been closed down and all work is now concentrated on the Deadwater Fell site on the English/Scottish border. The data presented here comes from this and these other two other sites. This poster describes the Deadwater Fell test site which was constructed in 1991 and is still in use today. Since 2005 it has been used specifically as part of the COST727 programme.

II. Introduction

The Deadwater Fell site has a test span and a rotating rig to test conductor samples (Figure 2.1). This rig is designed so that the samples are always facing normal to the prevailing wind. The main test span has two substantial H-poles set 200 m apart (Figure 2.2), each having two crossarms and 14 stay wires. These H-poles are designed to withstand impulsive forces from the galloping of large conductors and also to withstand blizzard conditions (Figure 2.3). Intermediate poles are installed as required for shorter spans. In the test spans, each conductor is fitted with a load cell and, if required, a vibration monitor. Video coverage can detect any galloping or rotation or general conductor movement under wind and ice loads. The spans are monitored 24 hours a day throughout the year by time lapse video cameras with low light level sensitivities down to 0.1 lux and which also allow a short period of real time coverage every 30 minutes. The cameras are mounted within specially adapted housings with insulation, internal heating and externally wound heating tape to reduce ice growth and are used to give close-up and long distance views using, if required, barely visible, environmentally friendly infra red floodlighting. Figure 2.4 shows a rotating rig under rime icing conditions.

Fig. 2.1 The southern H-pole of the Deadwater Fell main test span and the rotating rig.

Fig. 2.2 The main test span and measurement huts plus poles for infra red lighting at the test site. In this picture intermediate single poles have been erected for testing small conductor sizes.

Fig. 2.3 Blizzard conditions at Deadwater Fell.

Fig. 2.4 The rotating rig showing the two floodlights and a central video camera looking down on seven 1 metre long conductor samples.

Tests up to 2004 looked at 28 different conductor types using the rotating rig to compare ice accretion rates. This data was compiled into determining the ice accretion on conductors of different sizes. Since 2004 an attempt has been made to correlate data of conductor sizes from 6mm to 38mm diameter to determine the actual ice loads against conductor diameter. Figure 2.5 shows rime ice accretion sections taken from these conductors at one visit and Figure 2.6 a glaze icing sample. The data is presented in the following sections.

Fig. 2.5 Ice accretion samples from different conductors on test at Deadwater Fell.

Fig. 2.6 Glaze icing sample from a conductor under test

III. EQUIPMENT

A. *Monitoring system*

A detailed description of the test equipment at Deadwater Fell is given in another paper at this Workshop [3]. This section looks generally at the monitoring and logging equipment used.

B. *Video coverage*

The outputs from monochrome video cameras (Figure 3.1) viewing the spans are recorded in various time lapse video modes on an 8-channel digital video recorder (DCR) in a basic time lapse mode of 5 frames every minute, but with an optional 3 second pulse fed into the alarm input on the recorders every 20 minutes to one hour as desired. This gives a short burst of real video operation whilst still allowing the tapes to last 6 or 7 weeks. The DVR has a storage capacity of 160Gb.

Fig. 3.1 Heated video cameras used for each conductor

C. Load cells

Load cells monitor tension levels in the conductors. Each conductor is also mounted with a turn-buckle arrangement to enable tensions to be altered easily (Figure 3.2). This process is carried out from a platform built specifically for the purpose of accessing all the conductor monitors.

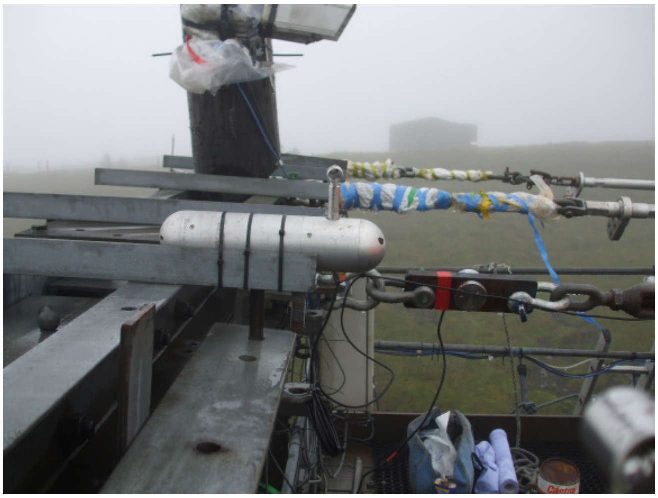

Fig. 3.2 Load cells and turnbuckles are installed on all conductors

D. Data acquisition

A data acquisition system and a measurement pod are used to collect data from various sensors. Marine weather resistant load cells are used to measure the conductor tensions. T type thermocouples, housed in miniature Stevenson screens, are used to measure temperature near the hut and at line height. Two anemometers (ultrasonic and cup) measure wind speed and Porton wind vanes monitor the wind direction. The outputs are set to a general 10 minute average and fed into the measurement pod. Barometric pressure, rainfall and relative humidity can be monitored if required.

The remote data logging equipment is automatically phoned and downloaded from EA Technology. In the event of a power or communications failure the loggers have in-built battery back-up systems. This allows them to keep storing up to 20 days of data. A Schlumberger 3590 Impact Data Acquisition System and an Isolated Measurement Analogue Pod 35951C are used to collect data from various sensors. The outputs are fed into a control box AU21HE019 and are set to a general 10 minute average, although 1 second logging can be set automatically in the presence of galloping. The output from the control box is then fed into the measurement pod. Barometric pressure is measured by a Vector P460/M transducer, whilst relative humidity is measured with a Skye SKH2010 sensor.

Each channel of the data acquisition system is programmed to suit its relevant input and conversion factors are included to read in units of each channel. The frequency of data collection is also programmed and the system can scan up to 100 channels, using a maximum of 5 measurement pods, every second. Each channel is programmed to be scanned every 10 minutes and the collected data is stored on a Data Tracker 2000/2600. The stored data is collected via a modem and mobile phone from EA Technology and is dialed up automatically every 12 hours, by Autodial software on an IBM PS2 computer, to download the collected data to the computer's hard disc. When the software has checked that the data is free from corruption it then erases the tracker store ready to accept fresh data, hangs up the telephone link and puts itself into sleep mode until the time comes to re-dial the remote site. The collected data can then be processed using Excel software to view the data and have a graphical output within minutes of contacting the sites.

The frequency that data is collected can be changed to monitor rapid responses of the conductor load cells to changes in wind direction or gusts. Time periods of one second are usually adequate for this task. The type of program can also be changed or the set up of each individual channel altered.

In the event of a power failure the Data Acquisition System and Tracker have in-built battery back-up systems. This allows the logger to keep working for up to 12 hours to ensure the loaded program continues to run. The Data Tracker 2600 can maintain its data store for 48 hours on the battery back up preventing the loss of data prior to the power failure. If the modem or mobile phone were to fail, and prevent communication taking place, the tracker can store 2 Mbytes of information, enough for 20 days of data.

E. Vibration monitoring

Various vibration monitors have been used in the past but over the last 4 years the site has used Sefag VIB400 monitors. The main aim in recent tests has been to compare the vibration performance of standard ‘conventional’ conductors with the new higher ampacity conductors. Figure 3.3 shows the installed monitors on various conductors under test.

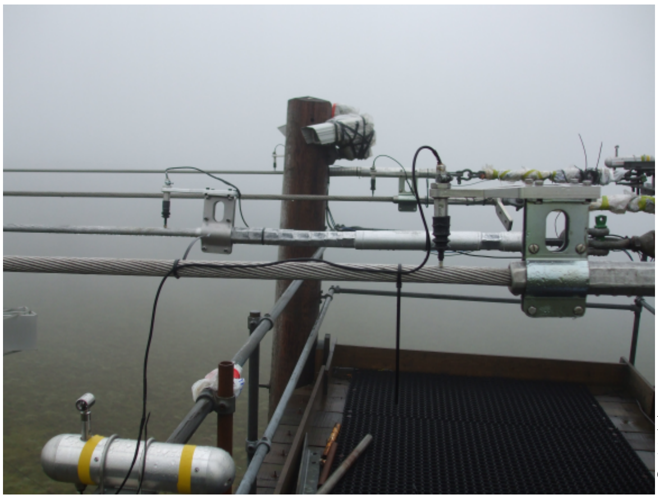

Fig. 3.3 Vibration monitors installed on all the conductors

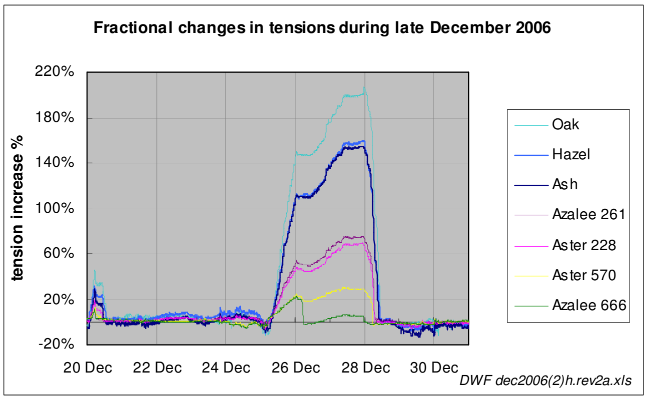

Fig. 4.2 Percentage increases in tension for conductors ranging from 14 to 31mm in diameter in December, 2006, showing the smallest conductor exceeding its design load whilst the largest conductors are hardly affected.

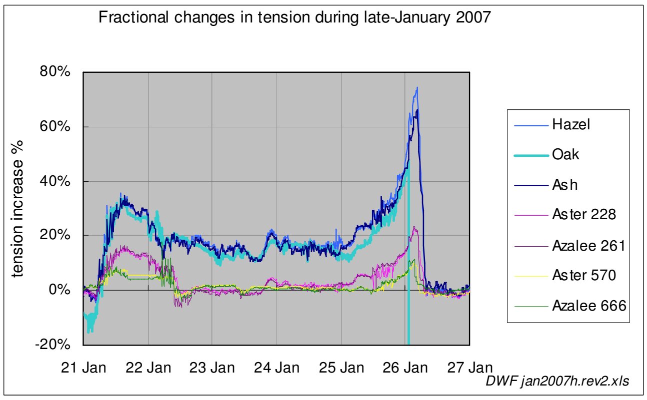

Fig. 4.3 Percentage increases in tension for conductors ranging from 10 to 31mm in diameter. The severe effect of wind/ice incidents on small conductors can clearly be seen

IV. Data

A. Typical incidents

As has been stated, attempts were made to determine the ice accretion rates on conductors of different sizes. This was initially made using short lengths of conductor on the rotating rig. The data, covering a total of 28 conductors, is shown in Figure 4.1. A more useful measurement technique, however, is to monitor conductor tension loads for a variety of conductors on the main test span at the same time. This latter method has more direct relevance to line design. In two periods of time during the 2006/2007 winter the percentage tensions in each conductor were measured and are shown in Figures 4.2 and 4.3. In Figure 4.2, the smallest conductor (14mm diameter) suffers loads doubling its erection tension (and hence its maximum design load) whereas the largest conductor (31.5mm diameter) suffers only a 20% increase in tension for the same weather conditions. Figure 4.3 also shows this for a smaller conductor (Hazel) which is just 9.9mm in diameter.

B. Main span ice data on different conductors

Data over successive winters (around 25 icing incidents) was used to investigate the effect of conductor diameter on ice accretion rates. The overall summary result is shown in Figure 4.4.

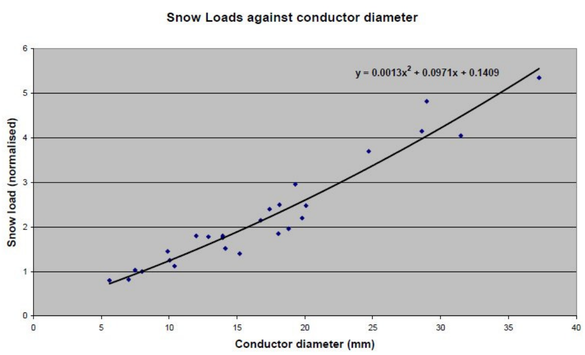

Fig. 4.1 Snow loads against conductor diameter for 28 conductors using data from the rotating rig. A polynomial fit is also shown.

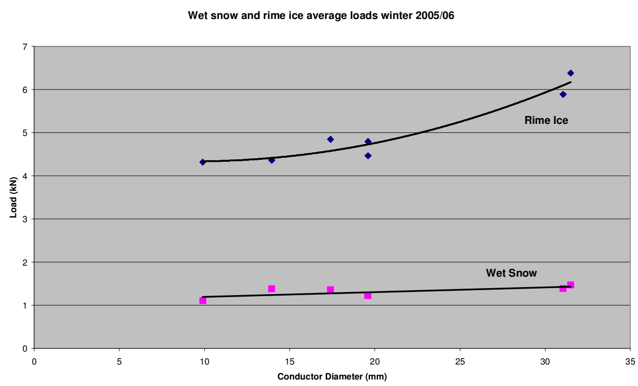

Fig. 4.4 Averaged rime ice and wet snow loads against conductor diameter from Deadwater Fell tests

Wet snow is the main source of high loads on overhead lines in the UK. It has long been known that smaller conductors suffer worse than larger conductors. However, the

UK standard still assume the same radial ice thickness whatever the conductor size. The Deadwater data shows that for larger conductors this assumption results in loads being overestimated by up to 100% and so forcing over-engineering into line design.

C. Main span wind only data

It was decided to look at the effect of wind on un-iced stranded and smooth conductors of similar sizes. This was done for two pairs of conductors of approximately 19mm and 31mm diameter. One conductor was made up of normal round strands and one with shaped strands (to give a smooth surface) at each diameter. Figure 4.5 shows the data for the 19mm conductors and Figure 4.6 for the 31mm conductors. There is a small effect for the smaller conductor size but no significant effect on the larger size.

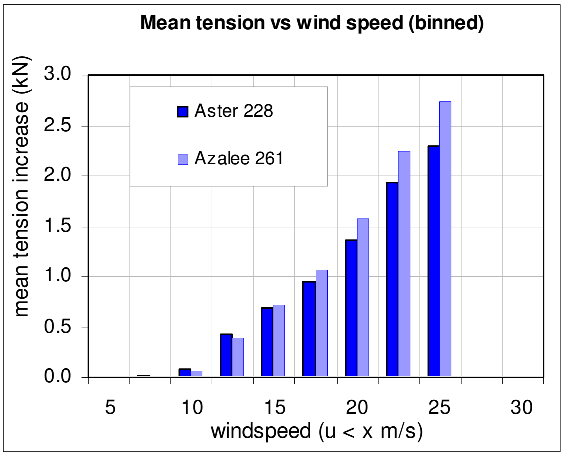

Fig. 4.5 Effect of wind only (no ice) on smooth (light blue) and stranded (dark blue) conductors of 19mm diameter

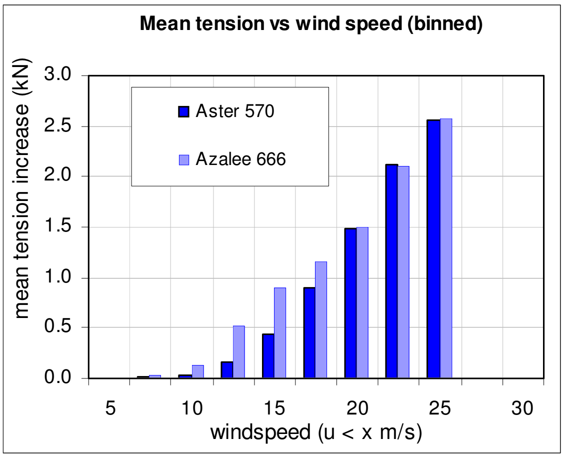

Fig. 4.5 Effect of wind only (no ice) on smooth (light blue) and stranded (dark blue) conductors of 31mm diameter

V. Icemeter tests for COST727

In line with requests from COST727, several icemeters were tested at Deadwater Fell in conjunction with the conductor icing tests. This allowed actual ice loads to be compared with icemeter data. It also allowed WRF modeling of snow and ice loads using the conductor data and the site's meteorological instrumentation. This work is reported separately at this Workshop [2].

Combi-Tech, HoloOptic and Goodrich instruments were tested at Deadwater Fell as well as the PMS Icemeter. The latter is reported separately at this Workshop [3].

The Swedish Combi-Tech IceMonitor is a 50 cm long, freely rotating cylinder which automatically weighs the total amount of ice accreted and the accretion rate (Figure 5.1).

The Goodrich/Campbell/Rosemount Canadian Icemeter is based on the principle of frequency changes due to the accretion of ice on a vibrating finger, yielding a yes/no answer. Icing rate indicated by frequency of heater de-icing (Figure 5.2).

The HoloOptic sensor uses an infra red beam noting the change in reflectivity of a surface as it ices up. Icing rate indicated by frequency of heater de-icing (Figure 5.3).

Fig. 5.1 The Combi-Tech ice monitor at Deadwater Fell

Fig. 5.2 The Rosemount icemeter at Deadwater Fell

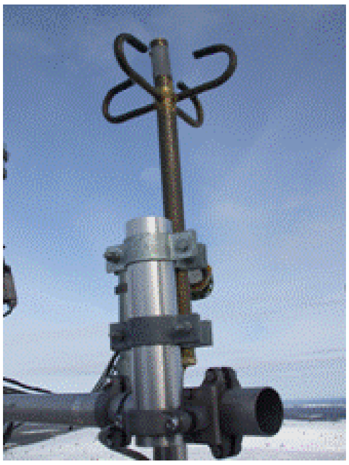

Fig. 5.3 The HoloOptic icemeter at Deadwater Fell

The data from the winter testing of these icemeters is reported separately at this Workshop [4]. However, the period of early March, 2009, is shown in Figure 5.4. Here the top graph shows the weather conditions, the middle one shows the tension levels (and hence the icing incidents) and the lower one the output from the three icemeters. The HoloOptics did not register any output whereas the Rosemount/Campbell records all three incidents. The Combi-Tech misses the first two incidents but registers the third.

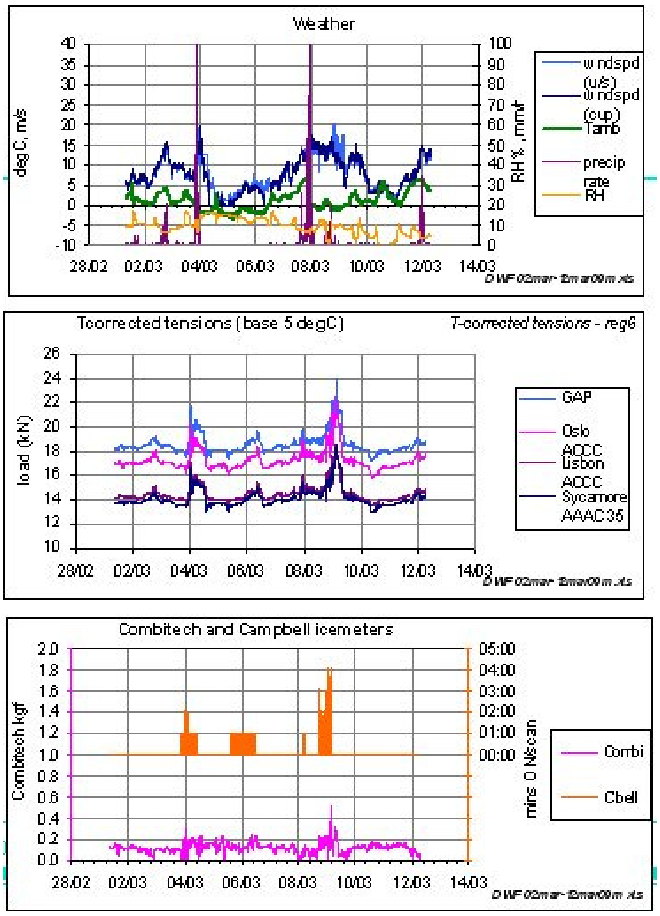

Fig. 5.4 Icemeter data from early March, 2009.

Figure 5.5 shows the incidents in late January, 2009. Overall during the winter there were 25 separate incidents. In this period both the Combi-Tech and the Rosemount/Campbell showed good agreement with the ice loaded conductor tensions but the HoloOptic again gave no output.

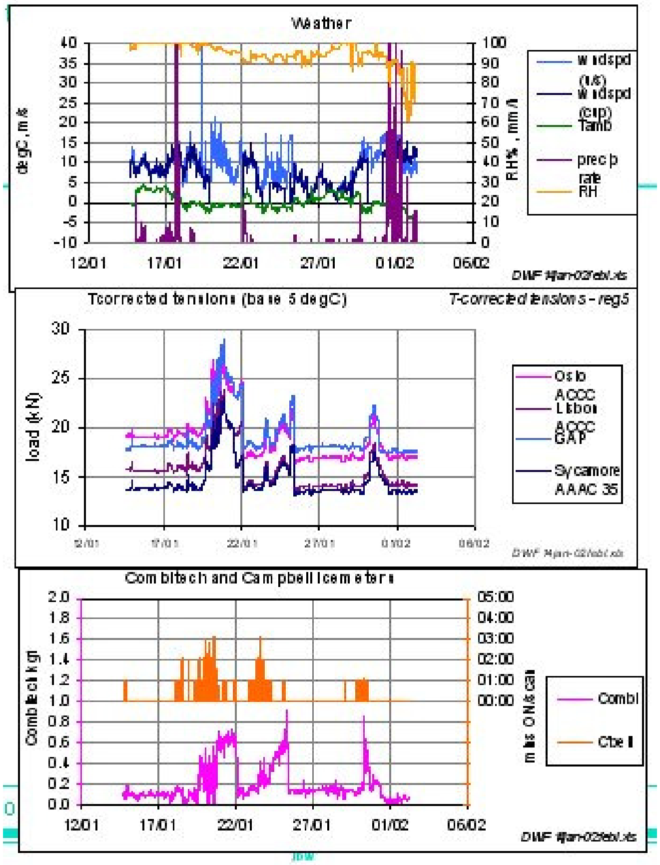

Fig. 5.5 Icemeter data from late January, 2009.

VI. SUMMARY

The site at Deadwater Fell is equipped with meteorological instruments and video and load cell monitoring of conductors on a 200m test span. Vibration monitors are also in current use on new conductor types. The site has been operational since 1991 and has been used to monitor wind and ice loads on various conductor types to aid line design and conductor choice for UK utilities. Over the last two winters it has been used to test three Icemeters as part of the COST727 programme.

The HoloOptic icemeter detected icing up to mid-December then the output went high due to an instrument fault.

The Combi-Tech IceMonitor generally indicated rime icing incidents but may have missed snow incidents. Some background noise was noted throughout.

The Rosemount/Campbell generally indicated incidents with no background noise

Overall there are still unresolved issues over wet snow indications from all the icemeters.

VII. REFERENCES

Papers Presented at Conferences (Unpublished):

[1] J. B. Wareing, "Deadwater Fell Test Site" presented at the 9th IWAIS, Andermatt, Switzerland, 2009. Poster PO. 067.

[2] J. B. Wareing and J Sabata, "Testing of the PMS icemeter at Deadwater Fell Test Site" presented at the 9th IWAIS, Andermatt, Switzerland, 2009. Poster PO. 069

[3] J. B. Wareing, "European Test Sites" presented at the 9th IWAIS, Andermatt, Switzerland, 2009.

[4] J. B. Wareing, "European Test Sites data on icing monitors and conductor ice loads" presented at the 9th IWAIS, Andermatt, Switzerland, 2009. Poster PO. 068