Using VantagePoint to Analyze **d-Cable** Data

YieldPoint Inc

Dec 2019

YieldPoint Sensing the future

Instrument properties

The instrument properties for a d-cable are entered in the instrument tab. Typical values are shown below.

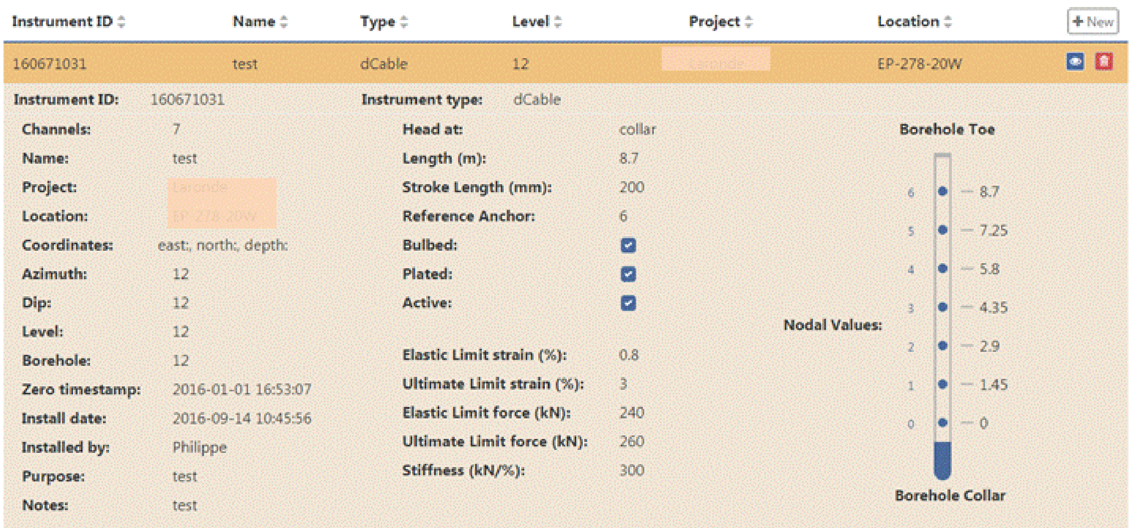

Figure 2: The Instrument form for a d-Cable

The ***d*-Cable** is based on a miniature borehole extensometer manufactured into a surrogate tubular king-wire. A total of up to six wires are fixed to the king-wire at nodal locations $x_1, x_2 \ldots x_6$. Node 1 is always closest to the head. The translation of the six wires is measured by 6 displacement sensors at the head of the device. As the cable stretches each displacement sensor measures the relative displacement between the head and the nodal point (u_1, u_2 ….u_6).

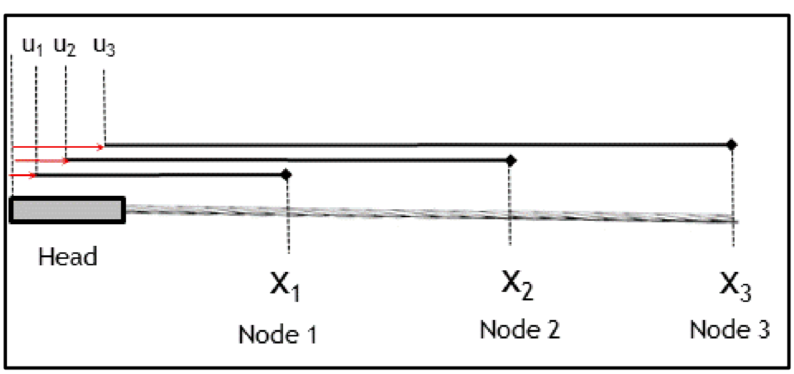

Figure 1: The d-Cable: Mode of operation.

The nodal points can be concentrated at locations where it is predicted that the cable may intersect a known geological feature. The location of the nodal points is specified by the customer.

The measured displacements need to be referenced to a point of zero displacement, which may not be the instrument reference head. In other words, if the instrument head moves then this must be accounted for. Two cases exist:

(i) Head-at-Collar.
(ii) Head-at Toe.

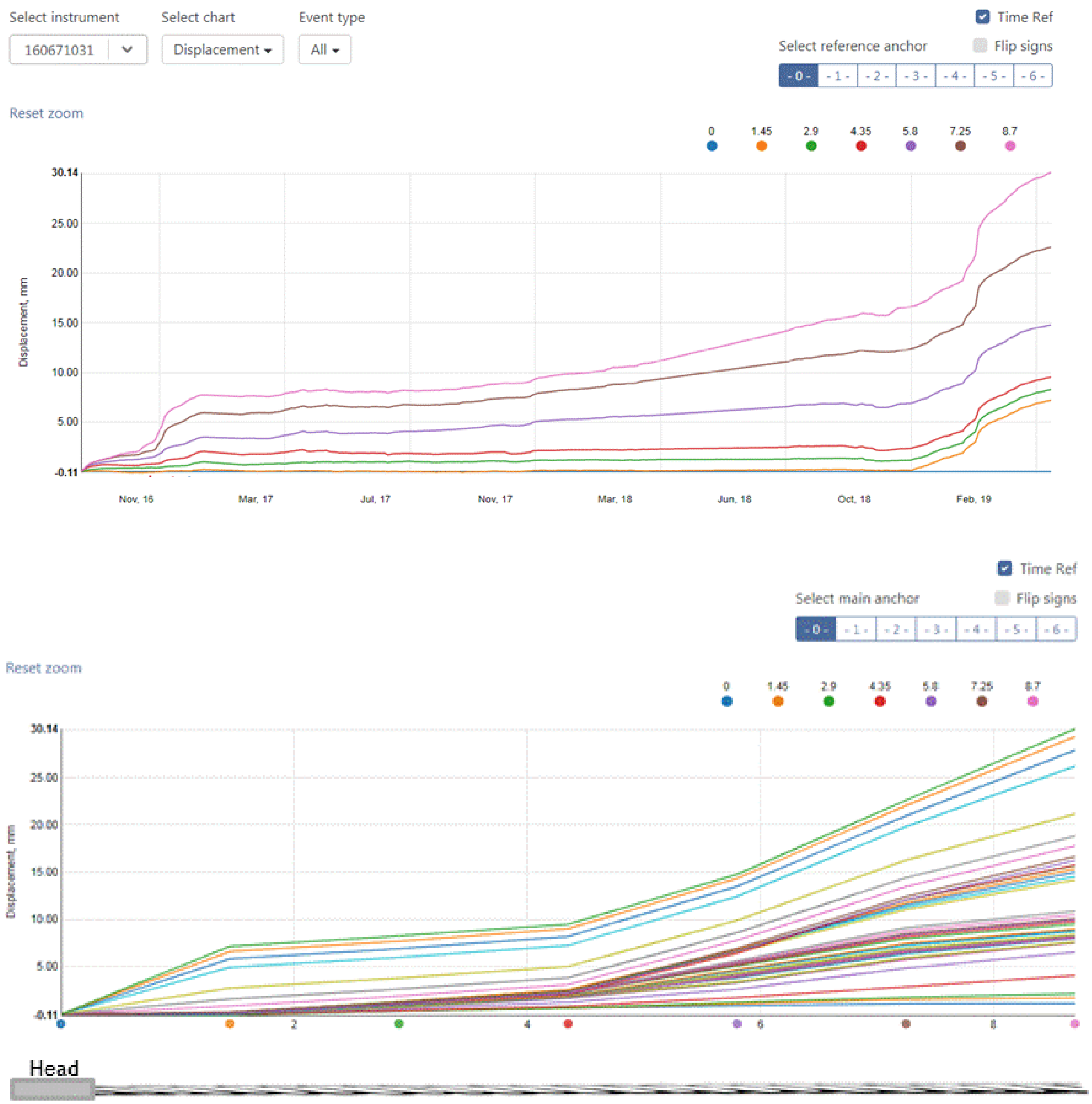

Figure 3: Temporal plot (top) and spatial (bottom) plots for displacement with the head (node 0) as reference. Suitable for HaT plated cables.

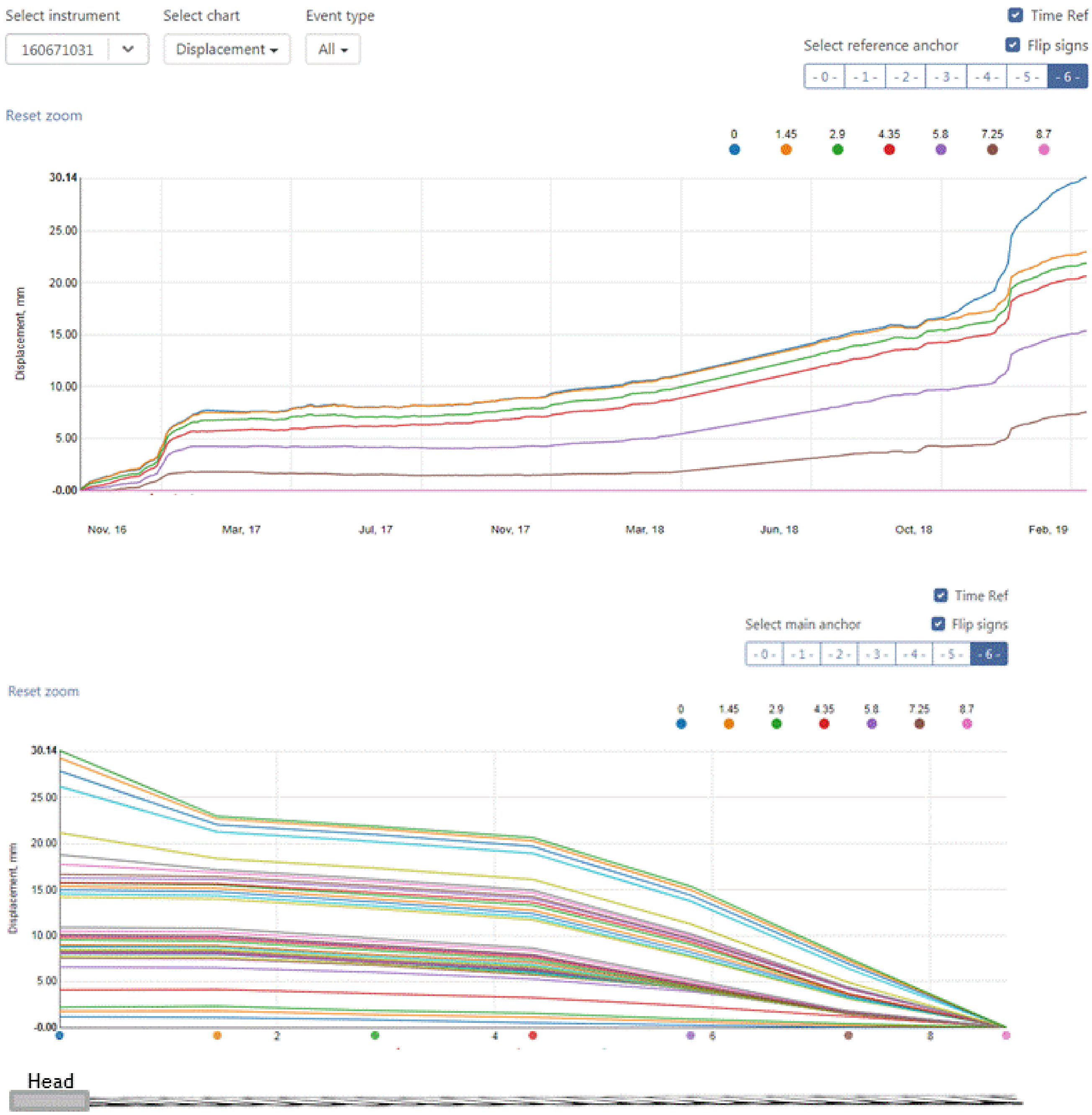

Figure 4: Temporal plot (top) and spatial plot (bottom) for displacement with the Toe (Node 6) as a reference. Suitable for unplated HaC d-cables

The former involves the instrument head being close to surface of the excavation, and hence moving. In this case the toe of the cable (node 6) is best nominated as the reference point Figure 4. The latter usually applies to cables that are plated and for which the head is recessed to the toe of the borehole.

Strain calculation

The difference between adjacent nodal points can be used to calculate the strain of the cable,

$$\varepsilon_{12}(\%) = \frac{u2-u1\ (mm)}{x2-x1(mm)} \text{x}100$$

or

$$\varepsilon_{12\ (\mu\varepsilon)} = \frac{u2-u1\ (mm)}{x2-x1(mm)} \text{ x } 10^6$$

where ε_{12} is the average strain between nodes 1 and 2.

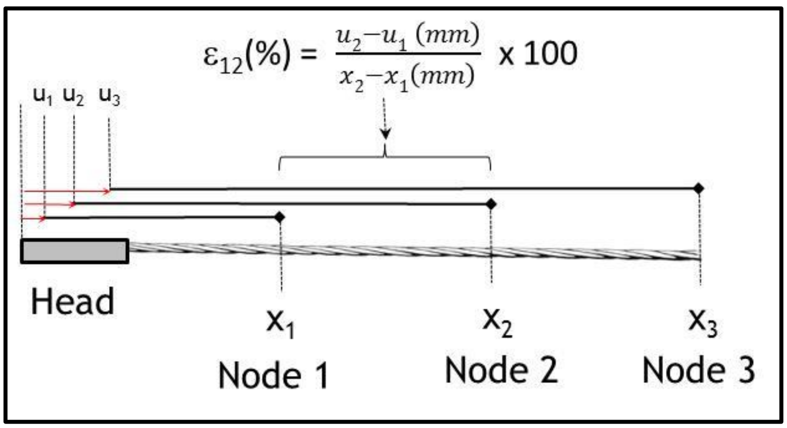

Figure 5: The d-Cable: Calculation of strain (%).

As such the strain is simply the slope of the displacement spatial plot. Since the value depends on two adjacent anchor point the value of strain is represented at the midpoint between nodes.

The Head of the cable is always set to sero since the axial load is zero as a boundary condition. Without a faceplate the same boundary condition applies to the toe of the bolt. However, if a faceplate is applied it is assumed that the load and hence strain at the faceplate is equal to that at the midpoint of noes 5 and 6 (ε_{56}) as shown in Figure 7. .

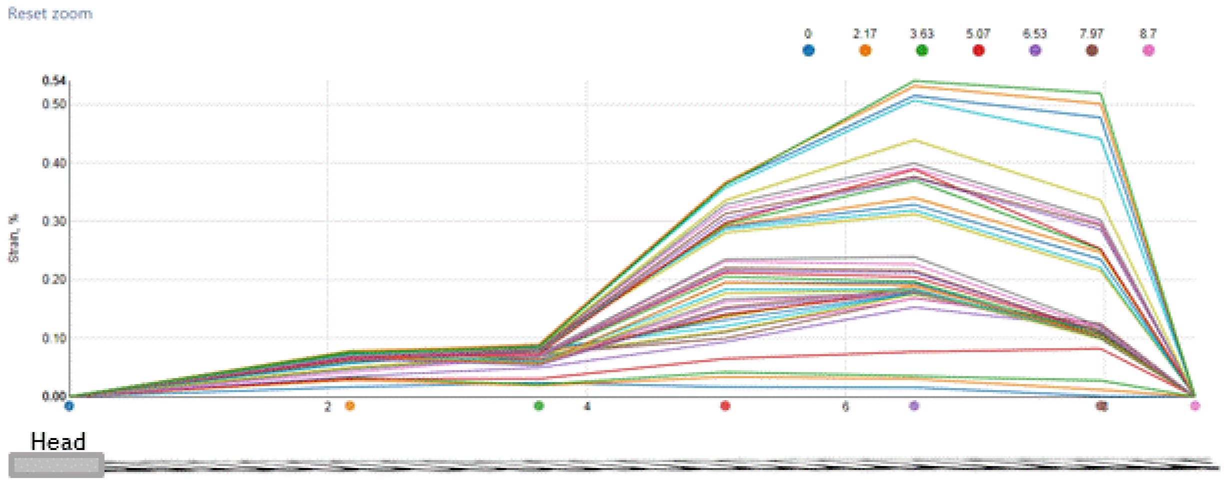

Figure 6: The spatial strain plot without a faceplate

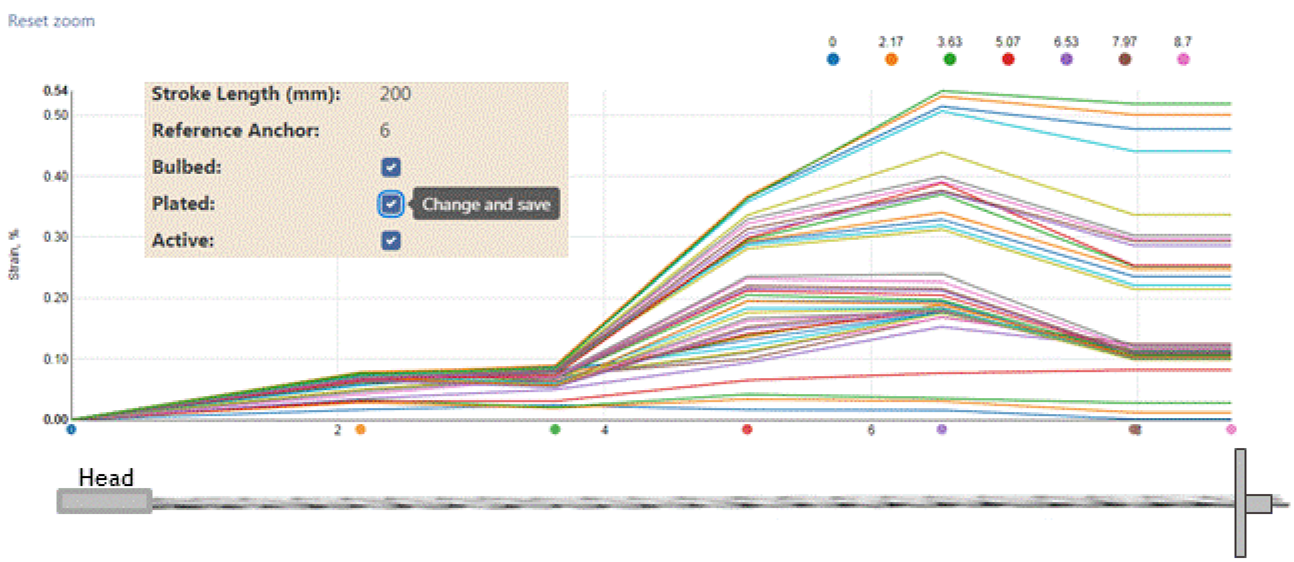

Figure 7: The spatial strain plot with a faceplate

Load Calculation

The corresponding load can be calculated based on by multiplying the strain (ε_{12} etc) by the stiffness of the cable (30N/$\mu\varepsilon$ or 300kN/%) up to the elastic limit. Beyond the elastic limit the stiffness is reduced to account for yield of the cable.

IMPORTANT: Strain rather than load should be used for engineering decision making beyond the elastic limit since small increases of load may be misleading.

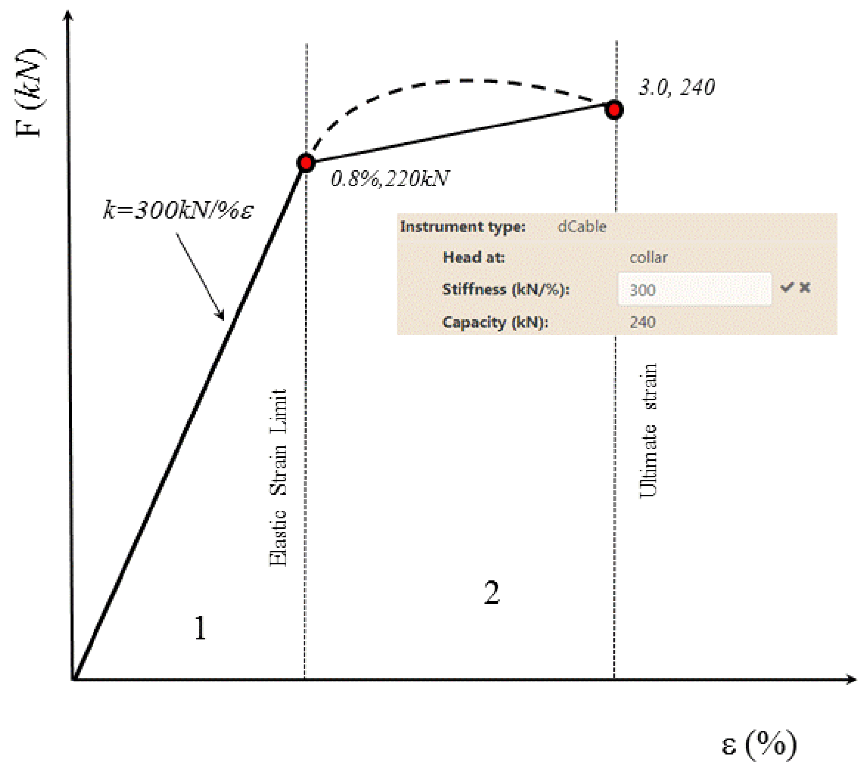

Figure 8: The bi-linear load-displacement profile used for determination of load

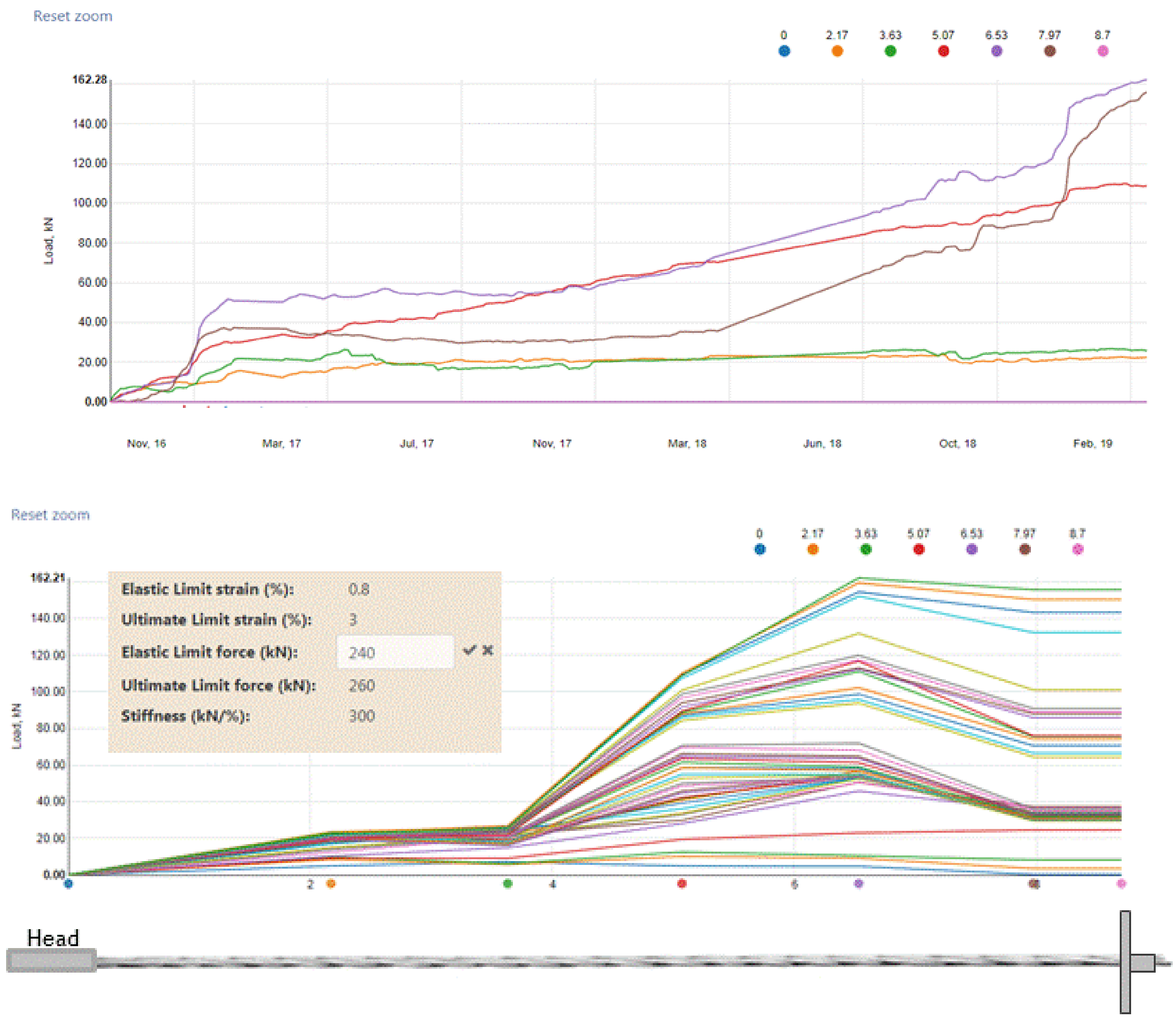

Figure 9: temporal and spatial plots for Load (kN).