TECHNICAL NOTE

Boxted Bridge ECC Br. No. 0059

Proving Load Test Commentary

December 2025

Document Control Sheet

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EXECUTIVE SUMMARY

This Technical Note provides conclusions and commentary on the Proving Load Test of 0059 Boxted Bridge, carried out on the 10th of September 2025, in accordance with CS 463. The load test and the associated monitoring were carried out by Accolade Measurements Limited, and independent monitoring was undertaken by Encompass Geospatial Limited. Ringway Jacobs/Essex Highways supervised the test.

Boxted Bridge was built in 1897 and is located on Wick Road/Lower Farm Road near the junction of Sky Hall Hill in Boxted on the Essex/Suffolk border where it crosses the River Stour. The structure comprises a single span steel girder 'half-through' bridge. The deck comprises jack arch construction and the bridge is supported on brick abutments.

The bridge is currently closed to vehicular and pedestrian traffic, following the findings of the 2023 Principal Inspection which identified significant defects and deterioration of the bridge.

The measured vertical deformations and rotations of the girders were generally as anticipated, except for the readings from the lateral movement gauges and the suspected minor settlement of the north abutment.

Based on the overall results it is concluded that there is sufficient evidence to justify re-opening of the bridge for pedestrians and cyclists over a 2m path through the centre of the bridge, including a necessary monitoring regime.

1. Introduction

1.1. Purpose of Technical Note

The purpose of this Technical Note is to provide commentary and conclusions from the Proving Load Test of Boxted Bridge carried out on the 10th of September 2025. The structure is sub-standard and currently under a full closure due to its condition. The Proving Load Test was conducted by Accolade Measurement Ltd. under the supervision of Ringway Jacobs/Essex Highways. The purpose of the test was to evaluate the bridge's suitability for potential re-opening for pedestrians and cyclists. The factual report from the test is contained in Appendix A.

1.2. Bridge Description

Boxted Bridge (OS grid reference: TM 01251 34422; What3Words: caskets.waged.boxing) is located on Wick Road within the Dedham Vale National Landscape and crosses the River Stour. The bridge is located on the north side of the junction of Wick Road, Skye Hall Hill and Lower Farm Road. The bridge straddles the Essex/Suffolk border and is located approximately 750m northeast of Boxted and 900m south of Thorington Street.

The structure is a steel girder bridge, constructed in 1897 by local engineer George Double. It is trapezoidal in form and consists of a single span steel deck supported by two substantial brick abutments at either side of the waterway. The deck comprises jack arch construction, with transverse built-up girders in the middle of the bridge and longitudinal rolled beams near the abutments. The main edge girders act as parapets and are painted dark green, and the approaches to the bridge are flanked by red brick pilasters with granite stone coping on top. It is oriented approximately north/south and used to carry road traffic over the River Stour. The south side is slightly wider (6.75m) than the north side (4.77m). It does not have any footpaths.

1.3. Bridge Condition

As noted in the June 2023 Principal Inspection, after which the structure was deemed as an immediate risk structure and has been closed to all users, the condition of the primary and secondary elements has deteriorated as highlighted below:

- The riveted plate girders (both the main edge girders and the secondary transverse girders in the deck) are exhibiting significant corrosion with section loss through both the webs and flanges throughout. These section losses affect the capacity of the structure and are also present at critical locations such as the supports and at mid-span. In areas of the east edge girder, the bottom flange has deteriorated completely with total section loss. There is section loss present at multiple stiffeners on both main edge girders with width losses of approximately 20-60%.
- A rivet head has become detached from the 1st transverse beam from the south side, at the end of the bottom flange plate (the bottom flange comprises three layers of plates riveted together).
- The bottom flange plates riveted to the transverse beams are significantly deflected (due to corrosion) at the ends of each plate throughout the deck, measuring between 20mm to a maximum of 80mm from transverse beams' bottom flanges. The plates are most affected on the east side, at the 3rd and 6th beam from the south.
- Several rivet heads within the secondary elements (transverse beams) which are subject to expansive corrosion have deteriorated further and are at increased risk of failure as the corrosion is expanding.
- The east edge girder had rotated inwards by 65mm measured midspan. The west edge girder had rotated inwards by 30mm measured at the north end.

1.4. Previous Assessment

The structure was assessed in 1992 in accordance with BD 21/84. The assessment found the superstructure to have a live load capacity of 3 tonnes, but this rating assumed that there is sufficient ‘U-frame’ action providing beneficial restraint for the edge girders against buckling.

The structure was monitored regularly following the assessment as no weight restriction (structural or environmental) was implemented.

A re-review of the 1992 assessment was undertaken by Ringway Jacobs/Essex Highways in November 2024, which recommended that the bridge should remain closed considering the assessment results and the condition based on the 2023 Principal Inspection, where the defects, including unexpected outward rotations of the girders, were considered as evidence of the ‘U-frame’ action being ineffective.

2. Proving Load Test

2.1. Test Methodology

Full details of the Proving Load Test are contained in the factual load test report attached in Appendix A. The methodology is summarised below.

The load test was carried out in accordance with CS 463. The pedestrian live load was simulated by a 3.4m x 3.4m water bag infilled with a prescribed volume of water, as shown in Figure 1 below. The volume was pre-determined to simulate the load effects of pedestrian traffic over a width of 2m through the centre of the bridge, i.e. 5kN/m^2 uniformly distributed load, multiplied by factors of safety of 1.1 x 1.5 = 1.65 in accordance with CS 454.

Figure 1. Boxted Bridge Load Test

The load was applied in multiple stages including 1 tonne, 7.4 tonnes and 16 tonnes, each followed by full unloading to check for recovery of displacement. The 7.4 tonnes load was equivalent to the characteristic pedestrian load, while 12.2 tonnes is equivalent to the factored ultimate limit state pedestrian load (16 tonnes were applied for additional margin).

During the test, the behaviour of the edge girders was evaluated using the following equipment:

- Displacement gauges measuring horizontal movement of the top flanges with respect to the deck, at mid-span and at the abutments,
- Inclinometers measuring rotation of the top flanges at mid-span and at the abutments,
- Digital optical level with 5 barcode staffs per girder, measuring vertical movement of the girders,
- Ambient and structure temperature sensors.

The behaviour of the bridge was evaluated by monitoring the magnitude and direction of vertical and horizontal movements of the main girders, the linearity of movement after each load increment, recovery following unloading and any other visual signs of distress. The previous assessment found the edge girders to be the critical elements governing the capacity, hence the test was focused on their behaviour.

Aside from Accolade's measurements, independent monitoring of the main girders was undertaken by Encompass Geospatial Ltd., using tilt sensors and total station data, with the sensors attached to the webs of the girders – see Appendix B for the monitoring report for more details.

2.2. Structural Analysis

Structural analysis was undertaken by Ringway Jacobs/Essex Highways to determine the expected behaviour of the bridge, the maximum deflections expected in the load test as well as to aid the interpretation of the results from the test. The structure was modelled in a finite element software Midas Civil, where the edge girders and the concrete deck were modelled using plate elements, and the secondary beams using line elements. The test load was applied as a uniformly distributed load representing the weight of the 3.4m x 3.4m water bag. The temperature variations measured during the test were also applied in the model. Only the superstructure was modelled, with pinned support conditions. Various forms of analysis were undertaken, including:

- Linear elastic analysis,
- Geometric non-linear analysis – with the test load and temperature changes applied in increments,
- Variations of the above analyses with and without assumed initial imperfections in the edge girders,
- Variations of the above analyses with and without 'U-frame' action, i.e. with either full or no rotational stiffness at the connection between the cross-beams and the edge girders.

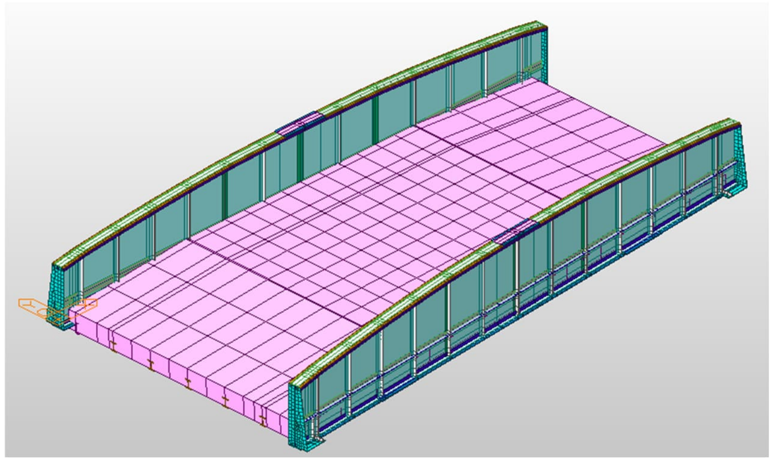

Figure 2. Boxted Bridge - Analysis Model

2.3. Results and Discussion

Full test results are provided in Appendix A and B of this technical note. The next sections provide additional processing and comment on the results.

2.3.1. Vertical Deformation

A comparison of the predicted vertical deformation and the measurements observed during the load test at the east girder is shown in Figure 3. The graph shows how the vertical movement varied during the test. The test measurements shown have been processed where the average movement of the girder at the abutments has been deducted from the mid-span displacement, such that the deformation of the girder itself can be compared directly to the analysis model, in which abutment settlement was not assessed.

The relative vertical deformation is generally very similar to the predicted values. However, from the analysis model, a final recovery of the girder's vertical deformation of approximately 90% was expected while the test showed approximately 70% (note: the overall vertical recovery was 32% when including abutment settlement, see Appendix A).

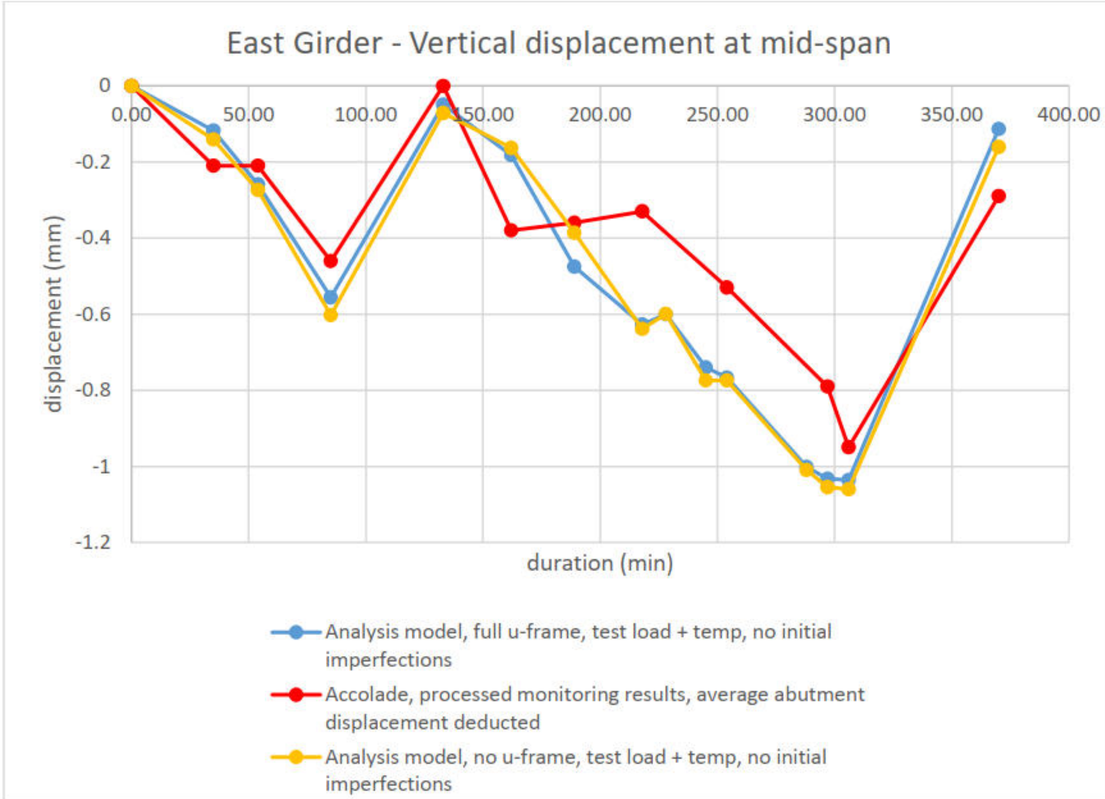

Figure 3. Boxted Bridge - mid-span vertical movement

Some of the difference between the predicted and the measured vertical deformation could be attributed to temperature variations. While the model included the effects of temperature change with each load increment, this has limited accuracy. For example, at various times some parts of the girder remained in shade while some were exposed to direct sun exposure during the test, which is not picked up by the analysis. Furthermore, Accolade confirmed that the vertical readings are generally reliable to a +/-0.3mm repeatability error which is large compared to the final deflection measured, and the differences between the analysis and the test results fall within this value.

During the load test, some vertical settlement without recovery has been noted at the north abutment's reference points after the final load was removed (see Appendix A):

- 0.7mm at location #5 (north-east corner)
- 0.5mm at location #10 (north-west corner)

It is possible that this settlement occurred due to the foundations 're-seating' considering the structure has not been subject to similar loads in a long time, since the bridge closure enforced in 2023. This settlement is not attributed to issues with the superstructure and is considered small considering the magnitude of the applied load.

2.3.2. Lateral Deformation

The structure is a half-through bridge, where the edge girders rely on the 'U-frame' action for stability against later-torsional buckling, which requires a sufficiently stiff moment connection between the edge girders and the deck. If adequate connections are provided, it is expected that the edge girders would rotate such that the top flanges would move laterally towards the bridge when load is applied onto the deck.

A comparison between the expected lateral movement of the top flange and the test measurements is shown in Figure 4 and Figure 5, where the sign convention is such that positive values indicate that the top flange is moving towards the bridge. The data has been 'zeroed' at the start of the incremental application of the 7.4 tonne load.

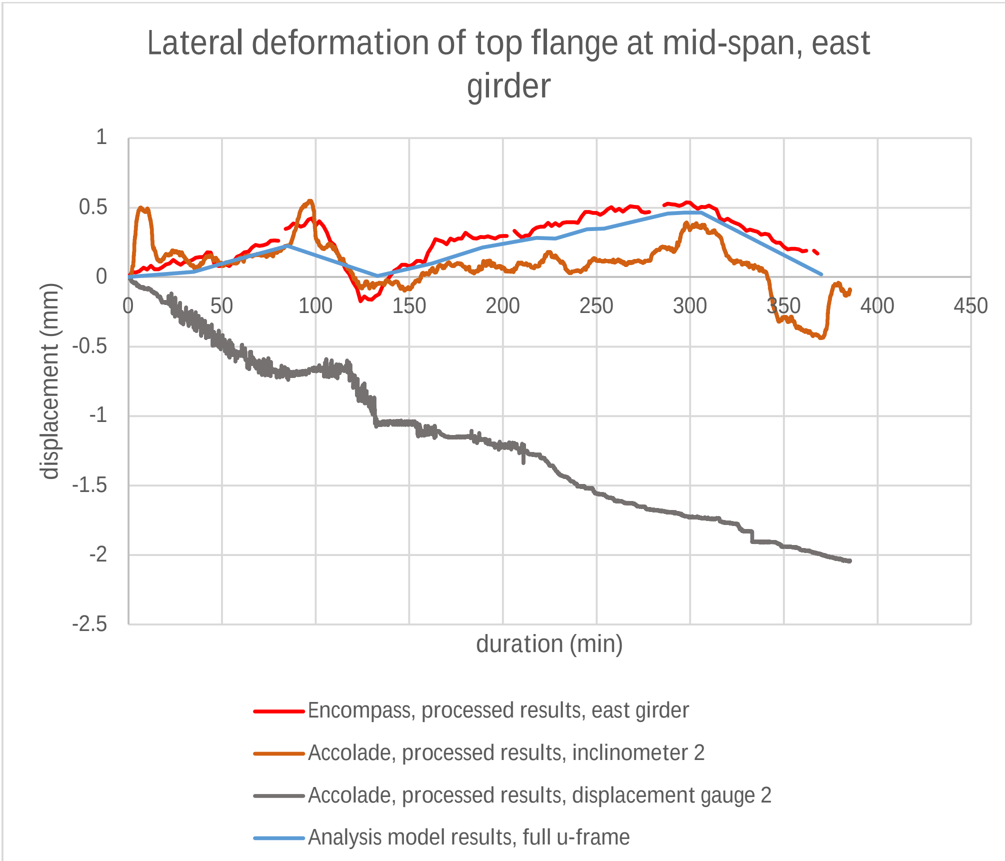

Figure 4. Boxted Bridge - east girder lateral deformation

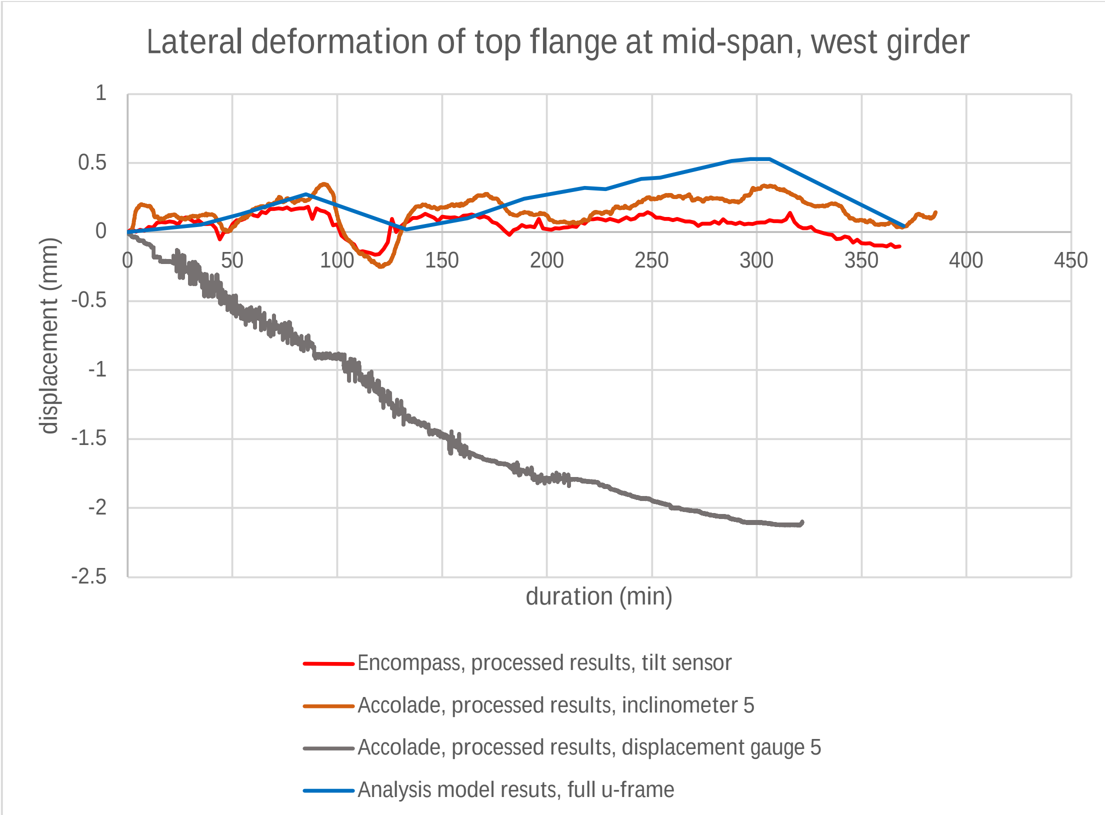

Figure 5. Boxted Bridge - west girder lateral deformation

The readings from the displacement gauges generally are not as expected, as they indicate outward movements of the top flanges. In order to verify this, the data from the tilt sensors and inclinometers was also processed and the angles of rotation converted to horizontal movement, assuming the whole girder cross-section rotates by the measured angle – the results are included in Figure 4 and Figure 5 as well.

The results from the converted inclinometer and tilt sensor data generally show the expected and desired behaviour of the girders, where the top flange moves towards the bridge as the test load is applied, and recovery can be observed when the load is removed. These results also match the output from the analysis model within a reasonable range, especially at the east girder. Similar to the case with the vertical measurements, the differences can be explained by the limited accuracy of temperature modelling, as well as unknown horizontal support stiffness, unknown details of initial imperfections of the girders, and no account of corrosion section loss in the analysis.

The difference between the results from the inclinometers used by Accolade and tilt sensors used by Encompass can also be explained by the fact that they were installed on the flanges and webs, respectively. Therefore, slightly different rotations can be expected in each element. Furthermore, the two types of equipment have different resolution. It is also important to note that Accolade's inclinometer results have been processed by averaging due to significant noise picked up in the data. Nonetheless, fairly similar behaviour, peaks and orders of magnitude can be observed from both rotation measurements.

The different results from the displacement gauges could be attributed to the fact that the poles which they were attached to were placed at some distance into the deck and hence they could be picking up the movement of the deck itself. No other reasons to doubt the measurements were identified. As the two different rotation sensors provide results which align within a reasonable margin, they are considered to take precedence over the horizontal gauge results.

2.3.3. Other Observations

During the load test, no visual signs of instability, wobbling, buckling or any other obvious distress were observed.

3. Conclusion

Based on the measurements from the Proving Load Test, it is concluded that there is sufficient justification to re-open the bridge to pedestrian and cyclist traffic over a 2m wide path through the centre of the bridge. The movements and recovery during the load test were as expected in most cases, with acceptable magnitudes of displacement and evidence of 'U-frame' action. Moreover, the day-to-day pedestrian loads will be significantly smaller than the applied test load.

However, considering the number of unknowns and a few unexpected results, monitoring of the structure is considered essential, in particular for the lateral movement of the top flanges and any abutment settlement.

4. Recommendation

The following actions are recommended:

1) Re-open the bridge to pedestrians and cyclists only, with a 2m wide path through the centre of the bridge as investigated by the Proving Load Test.

2) Undertake monitoring of the superstructure movements over a minimum period of 12 months from the date of re-opening to pedestrian/cyclist traffic. The full monitoring specification should be prepared in accordance with Appendix A2 of CS 470. As a minimum this should include monitoring of the edge girders' vertical deformation, lateral movement of the top flanges, rotation, and abutment settlement.

5. THE ABOVE IS SUBMITTED FOR ACCEPTANCE

Signed	[redacted]
Name	
Engineering Qualifications	
Name of Organisation	Ringway Jacobs
Date	As Above

THE ABOVE IS REJECTED / ACCEPTED AND RECOMMENDED FOR ACCEPTANCE

Signed	[redacted]
Name	
Engineering Qualifications	
Name of Organisation	Ringway Jacobs
Date	As Above

THE ABOVE IS REJECTED / AGREED SUBJECT TO THE AMENDMENTS AND CONDITIONS SHOWN BELOW

Signed	[redacted]
Name	
TAA	Essex County Council
Date	As Above

Appendix A. Proving Load Test Factual Report

Boxted Bridge Proof Load Test

Produced for Essex Highways

Document Number	3384-T03
Revision	02
Issue Date	26/09/2025

	Revision	Author	Reviewer	Notes
Names Date	1	[redacted]	[redacted]	Draft for comment
Names Date	2	[redacted]	[redacted]	Removal of 'pass' or 'fail' status outcomes.

Executive Summary

A proof load testing was conducted on Boxted Bridge, Wick Road, Essex in accordance with *DMRB CS 463 Load Testing for Bridge Assessment*. A preliminary test permitted limited personnel access on to the bridge deck, followed by a setting load and full proof load test. The content of the test was aimed to confirm or deny the limiting capacity associated with lateral torsional bucking, particularly U-frame connections, of the main girders. Test magnitude was determined such to demonstrate the bridge could be re-opened for a 2m wide lane for pedestrians and cyclists only.

Load was applied using a water bag to a maximum static load of 16tonnes. The bridge was monitored using a combination of precision optical levelling and a data acquisition system recording horizontal displacement of top flanges relative to the deck, global inclination of the top flanges and temperatures.

Testing was conducted on 9th & 10th September 2025.

This report presents factual data of the test. Results show behaviour within the stop criteria in all except the recovery of vertical displacement/deformation. An approximated recovery of 52% is measured compared to the desired criteria of 90%.

Figure 1 - Load testing of Boxted Bridge (load shown is approaching 12.2 tonnes)

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1. Background

Accolade Measurement Ltd. was appointed by Essex Highways to install a temporary monitoring system and undertake a proof load test on Boxted Bridge, Wick Road, Essex, under the oversight of Test Supervisor [redacted] Principal Design Engineer Structures for Essex Highways, in accordance with DMRB CS463 *Load Testing for Bridges* and the ICE *Bridge Testing Guidelines for Supplementary Load Testing (1997)*.

Boxted Bridge is a single-span half-through steel girder structure with transverse U-frame restraints. The structure carries a local road over the River Stour and is currently closed to all traffic following concerns raised during structural assessment. Numerical analysis indicated potential instability of the main girders under dead load due to insufficient lateral torsional stiffness, with connections to the transverse beams critical to U-frame action. The analysis provided no assurance as to the bridge's residual capacity or its ability to resist live load.

The primary objective of the test was to evaluate the bridge's behaviour under controlled loading and to assess its suitability for potential reopening to pedestrians and cyclists. Given the uncertainty over its capacity, testing was implemented in three stages: an initial preliminary load applied without personnel on the structure to confirm safety, a setting load and a staged incremental loading to the target load.

Loading was applied in a staged manner using a water bag and calibrated flow meter. The bridge was monitored using a combination of precision optical levelling and a data acquisition system recording horizontal displacement of top flanges relative to the deck, global inclination of the top flanges and temperatures. Testing was carried out under a road closure and controlled exclusion zones to ensure safety at all times.

Key features of the test included:

- Loading equipment: rated water bag, calibrated flow meter.
- Survey and measurement: digital optical level, 10 vertical barcode staffs, 4 reference points.
- Sensors and monitoring: 6 displacement gauges, 6 inclinometers, ambient air and structural temperature sensors, battery-operated data acquisition system.
- Site implementation: setup, real-time monitoring during testing, and removal on completion.

Real-time data was displayed on site throughout the test. All results were stored locally, remotely backed up and have been compiled into this factual report. Essex Highways provided site management, welfare, traffic management, and water supply during the works.

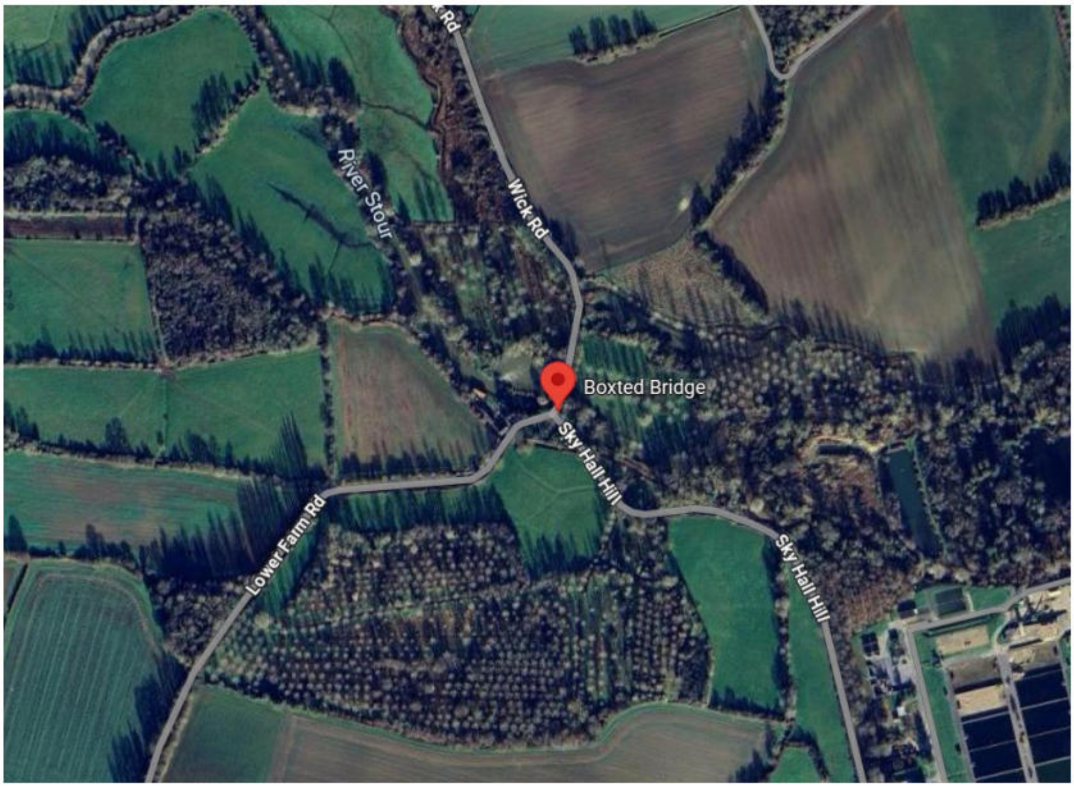


Figure 2 Test location (Google Maps)

Figure 3 Boxted Bridge (Public Imagery)

2. Conditions

All times stated in this report are local British Summer Time (BST), with the data acquisition system synchronised to an NTP time server.

Site setup and a preliminary load test were carried out on 9th September 2025. Weather conditions were fine, bright, and dry. Air temperature was not monitored at this stage.

System checks and the main load test were conducted on 10th September. Weather was changeable, with strong gusting winds and showers during the test, followed by persistent rain in the afternoon. Air temperatures fell from approximately 20 °C late morning to 16 °C by late afternoon. Periods of bright sunlight were notable, where temperature on the steel surface (taken on the shaded face) are seen to rise.

The bridge and all approach roads were closed to traffic and pedestrians for the duration of testing, with access restricted to authorised personnel only. A managed exclusion zone was enforced throughout.

After the preliminary test (1 tonne), it was confirmed that access for a maximum of 3 persons (approximately 1/3 of the test load), would be allowed on the bridge at one time. At any point, no persons were allowed on the bridge during the application of water weight, until sufficient water had been removed to assure the bridge capacity for up to 3 persons.

Water levels in the River Stour beneath the bridge remained stable and did not influence testing.

No movement or instability was observed at the sensor mountings. However, the support for horizontal displacement sensor #5 at mid-span of the west girder was moved by contact with the water bag during the final load increment (16 tonnes). Data from that sensor at the affected increment has been noted, but excluded from the graphical representations.

3. Health, Safety, Environment & Quality

HSEQ matters noted during the testing include:

- No personnel injuries or incidents were recorded during the load test or associated setup and removal activities.
- No movement or instability was observed at the sensor mountings. However, the support for horizontal displacement sensor #5 at mid-span of the west girder was moved by contact with the water bag during the final load increment (16 tonnes). Data from that sensor at the affected increment has been noted, but excluded from the graphical representations.
- There was general public interest in the testing. All interactions were friendly and factual. Members of the general public took photographs of the test position. All operatives maintained full PPE and compliance to the method statement.
- At the conclusion of testing, a full litter and debris sweep was undertaken to ensure no materials were left on site.
- Survey pins embedded into to road for datum points were fully removed after testing.

4. Loading

The loading regime was developed jointly by Accolade Measurement Ltd. and Essex Highways, with stop criteria and hold points agreed in advance. Testing was undertaken in four distinct phases over two days.

On the first day, a preliminary load of 1 m^3 (1 tonne) of water was applied using a water bag of 3.4x3.4m plan x1.8m high, and then unloaded. This initial stage was completed without personnel standing on the bridge and confirmed that the structure could safely support up to three persons and monitoring equipment. Measurement equipment was installed ready for day two.

On the second day, a repeat 1 tonne setting load was applied and removed, followed by the staged proof load test. Water volume was increased in controlled increments to 7.4 tonnes, representing the serviceability load. Load removed, confirmed elastic recovery. Monitoring confirmed the bridge to be stable, with minimal displacement and the test proceeded to the target load of 12.2 tonnes, corresponding to the calculated ultimate limit state bending moment (322 kNm) imposed by pedestrian/cyclist loading over a 2m wide track down the bridge centreline (at $5kN/m^2 \times \gamma_{fL} \times \gamma_{f3}$). Data and observations found no cause for concern.

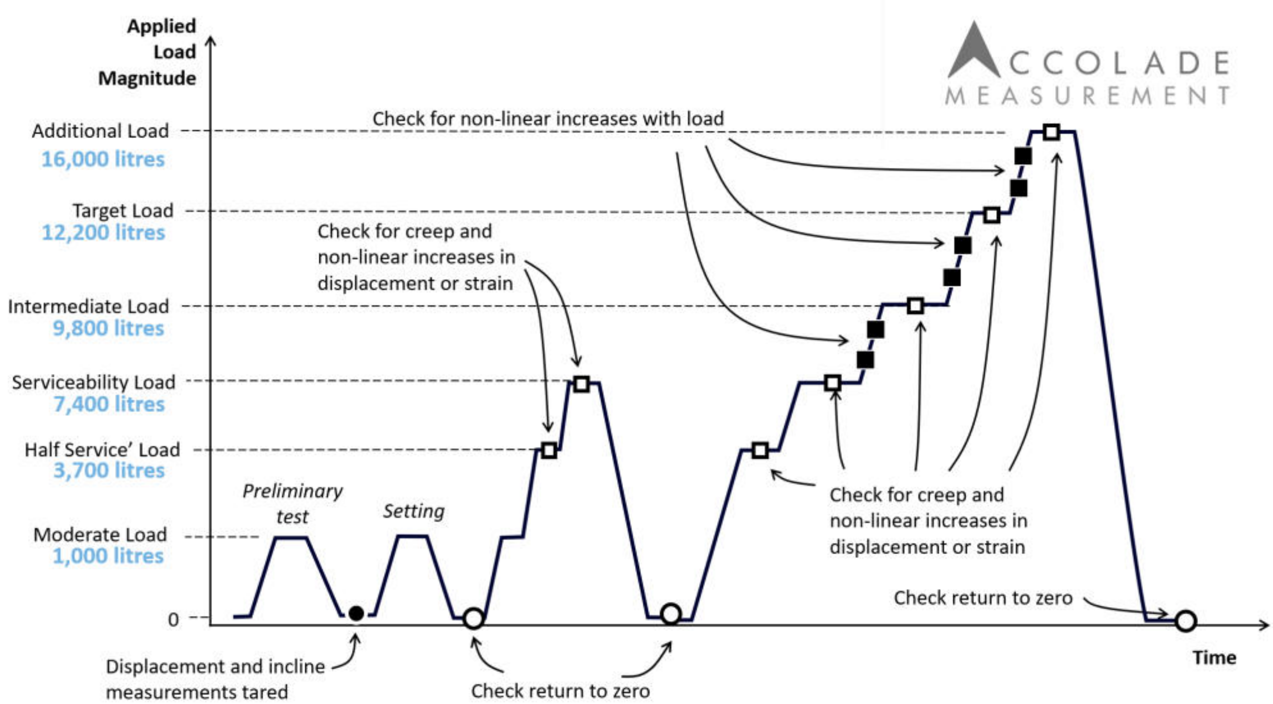
At the request of Essex Highways Test Supervisor, the maximum applied load was subsequently increased to 16tonnes. A point-of-work risk assessment was undertaken to accommodate this revised requirement before proceeding.

At each increment, displacement and rotation measurements were recorded and assessed against the predefined stop criteria. Loading would have been halted immediately if any limits were approached or exceeded, ensuring the safety of the structure and all personnel – but none occurred.

Test Cycle Overview

Load applied in one water bag (3.4x3.4m deforming in the test to a circular plan area of 4.5m diameter) at mid-span centrally between the two girders was incrementally raised and lowered to create a bending moment shared between the two girders (assumed equally).

Time	Configuration	Water in bag	Bending Moment	Hold period
Day 1	One bag roughly dragged to centre of deck. Observation by eye for movements	0	-	N/A
		1,000 litres	26 kNm	20 mins
		0	-	20 mins
Day 2	One bag positioned mid-span, mid-width. All instrumentation recording.	0	-	5 mins
		1000	26	20 mins
		0	-	20 mins
		1000	26	20
		3,700	98	20
		7,400	195	20
		0	-	20
		3,700	98	20
		7,400	195	20
		9,800	259	20
		12,200	322	20
		16,000	422 kNm	20
		0	-	20



Operational Controls

Testing was governed by a series of predefined stop criteria. At any stage, if any of these thresholds were reached, or suspected to have been reached, loading was halted immediately. Only the Test Supervisor was authorised to decide whether testing could proceed, and any such decisions were formally recorded.

- Maximum values – Numerical limits were established for measured or calculated responses (e.g. displacements, rotations). Exceeding these values required testing to stop. *At no point did any measurement approach the predefined limits.*
- Linearity values – Structural response was assessed incrementally as load increased, using the ratio Δx/ΔL. A reduction in linearity, indicating possible yielding or softening, was taken as a warning sign and grounds to halt loading. *Movements measured were so small (and the earlier vertical measurements were in the realms of measurment repeatability) that linearity was not possible to check with confidence. No measurable non-linearity could be detected.*
- Recovery values – Structural behaviour during unloading was compared with maximum values recorded under load. Insufficient recovery would have indicated potential residual deformation. Allowance was made for bedding-in effects, with repeat load cycles used to confirm whether observed behaviour reflected genuine distress. *Recovery of vertical load is estiamted at 32% after maximum load. It is possible that with a longer time after the test was completed, further recovery would be measured, but time did not permit.*

These criteria ensured that the bridge response remained within safe tolerances and that the test could be concluded without compromising structural integrity. The designated Test Supervisor held responsibility for verifying overall structural safety during the test.

Measurements on the data logger were captured at 1-second intervals using a time-synchronised data acquisition system. Displacement gauges were not re-zeroed between passes to allow recording of cumulative response and confirmation of elastic recovery following unloading.

Predetermined values for Stop Criteria provided by Essex Highways were as follows:

Measurement	Max.	Linearity	Recovery	Notes
General observations by eye	N/A	N/A	N/A	Any signs of instability, wobbling, buckling
Total vertical movement	50mm	85%	90%	Total movement may include contribution from abutment, support points, girders, cross girders, surfacing etc.
Total horizontal movement	N/A	N/A	N/A	NOT MEASURED
Girder vertical deformation	15mm	85%	90%	Mid-span vertical displacement minus average of movement at each end of the same girder.
Girder lateral deformation at abutments	15mm	85%	90%	Lateral displacement relative to the deck surface – i.e. caused by rotation of girder and/or U-frame connection to deck

Measurement	Max.	Linearity	Recovery	Notes
Girder lateral deformation at mid-span total	15mm	85%	90%	Lateral displacement relative to the deck surface – i.e. caused by rotation of girder and/or U-frame connection to deck
Girder lateral deformation along length	15mm	85%	90%	Lateral displacement relative to deck at mid-span, minus the average at each end of the same girder, indicating a twist or buckle.
Girder top flange tilt at abutments absolute	initial + 1 deg.	85%	90%	Absolute incline of top flange relative to horizontal (gravity referenced). *This may be notable before any load is applied.*
Girder top flange tilt at mid-span absolute	initial + 1 deg.	85%	90%	Absolute incline of top flange relative to horizontal (gravity referenced). *This may be notable before any load is applied.*
Top flange rotation at abutments	1 deg.	85%	90%	Change in incline from start of test.
Top flange rotation at midspan	1 deg.	85%	90%	Change in incline from start of test.
Girder top flange twist	1 deg.	85%	90%	Change in incline from start of test, mid-span minus the average of both ends of the same girder.

5. Measurement and Data Acquisition

Instrumentation was installed to monitor structural response during the load test. The system is designed to capture accurate, time-synchronised measurements of structural response. The digital data acquisition system was augmented with manual measurements from the analogue water flow meter and the precision optical level. Detailed notes were kept throughout the testing.

Load Measurement

Applied load was quantified using an in-line calibrated water flow meter connected between the bowser and the test bag. The meter recorded cumulative volume to a resolution of 0.01 m³ (equivalent to 10 kg of water mass). This enabled direct calculation of the applied load throughout filling and unloading, with readings taken continuously during each increment. Calibration certification for the flow meter is provided in Appendix B Calibration details.

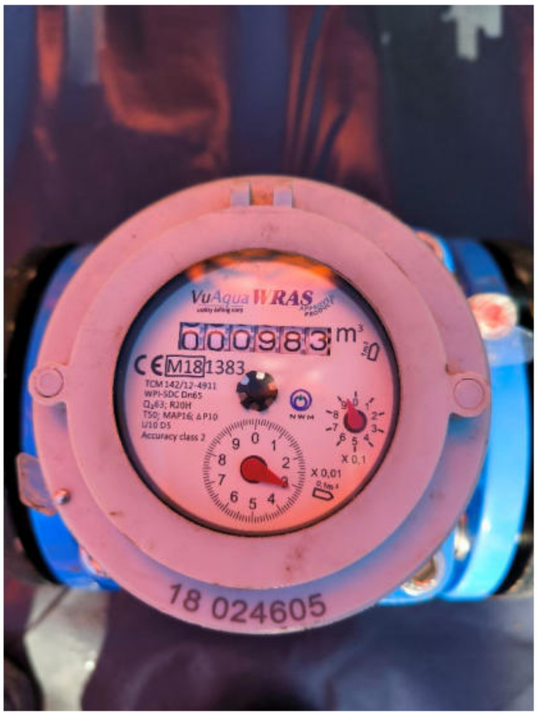


Figure 4 Calibrated analogue water flow meter (reading shows 983.931 m³)

Vertical Displacement Measurement

Vertical displacements of the bridge deck were measured using a Leica LS15 digital precision level in conjunction with barcode staffs fixed to the bridge girder top flanges. Four fixed reference points were established off the structure to provide stable benchmarks, against which relative movements of the deck could be determined. Ten monitoring positions were distributed along the deck to capture vertical deformation of the main girders under applied loading.

The Leica LS15 provided a resolution of 0.01 mm, with a repeatability of ±0.3 mm. Readings were taken at each load increment and after unloading, enabling assessment of both immediate displacement and elastic recovery.

Measurement positions and referring s are shown in Figure 10.

Figure 5 Leica LS15 Precision optical level positioned behind the south abutment (shown targeting the farthest measurement point on the west girder)

Figure 6 Typical 500mm barcode staffs clamped to the top flange, set vertically

Horizontal Displacement Gauges

A total of six linear displacement potentiometers were installed to measure the horizontal lateral deflection of the edge girders at top flange level relative to the deck surface. Sensors were mounted on weighted steel posts, providing a stable and adjustable support system. Each device offered a measurement resolution of 0.01 mm. The sensing tips were fitted with neodymium magnets, connecting to the girder top flange.

Gauge numbering and positions are shown in Figure 10.

Figure 7 Displacement gauge mounted to weighted steel post

Inclinometers

Six inclinometers were installed to monitor the rotation and of the girder top flanges. Instruments were magnetically mounted directly to the girder top flange, aligned to their longitudinal centreline. Each inclinometer offered a resolution of 0.01° and repeatability of ±0.05°. The devices were oriented perpendicular to the girder span to capture lateral movement associated with U-frame stiffness of the girders.

Gauge numbering and positions are provided in the appendix drawing.

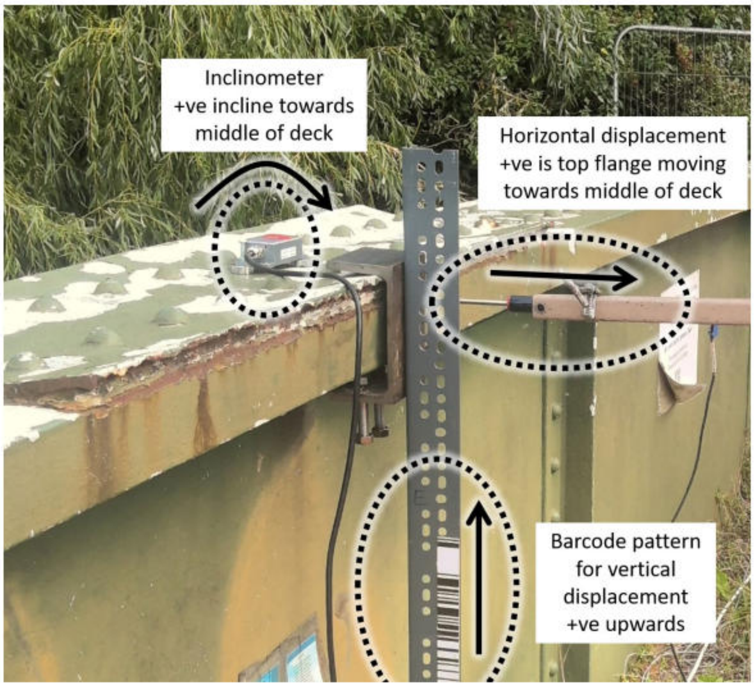


Figure 8 Inclinometer magnetically mounted to girder top flange, directions of sensing and sign conventions

Temperature Sensors

Two PT100 resistance temperature detectors were installed to record thermal conditions during testing. One sensor measured ambient air temperature, while the other was fixed to the steel girder surface to capture local structural temperature. Both sensors were mounted on the west side of the structure in a shaded position, minimising direct solar influence. Each offered a measurement resolution of 0.01 °C and repeatability of ±0.1 °C. This provides comparison of thermal effects against recorded structural movements and a baseline reference for any future repeat testing.

Data Acquisition System

All sensors were connected to a Campbell Scientific CR1000X data acquisition system, housed in a weatherproof IP67-rated enclosure and powered by sealed internal batteries. The system was configured to log:

- 6 lateral displacement potentiometers
- 6 inclinometers
- 2 PT100 temperature sensors (air and steel girder)

Sampling was carried out at 1 Hz. The logger clock was synchronised to a network time protocol (NTP) server prior to the start of testing, ensuring consistency of timestamps across the dataset. Real-time data displays were available on site to support live monitoring and verify system performance.

All sensors were zeroed at the start of Day 2 prior to the commencement of the full load test. Functional checks were performed before filling commenced to confirm correct operation of all sensors and data channels.

Sensors were not re-zeroed between load increments, allowing for monitoring of cumulative displacement and assessment of elastic recovery during unloading.

All recorded data were securely stored and downloaded after the last test sequence. Files were archived in CSV format, with processed datasets of displacement, inclination, and temperature included in Appendix A.

Figure 9 General testing layout

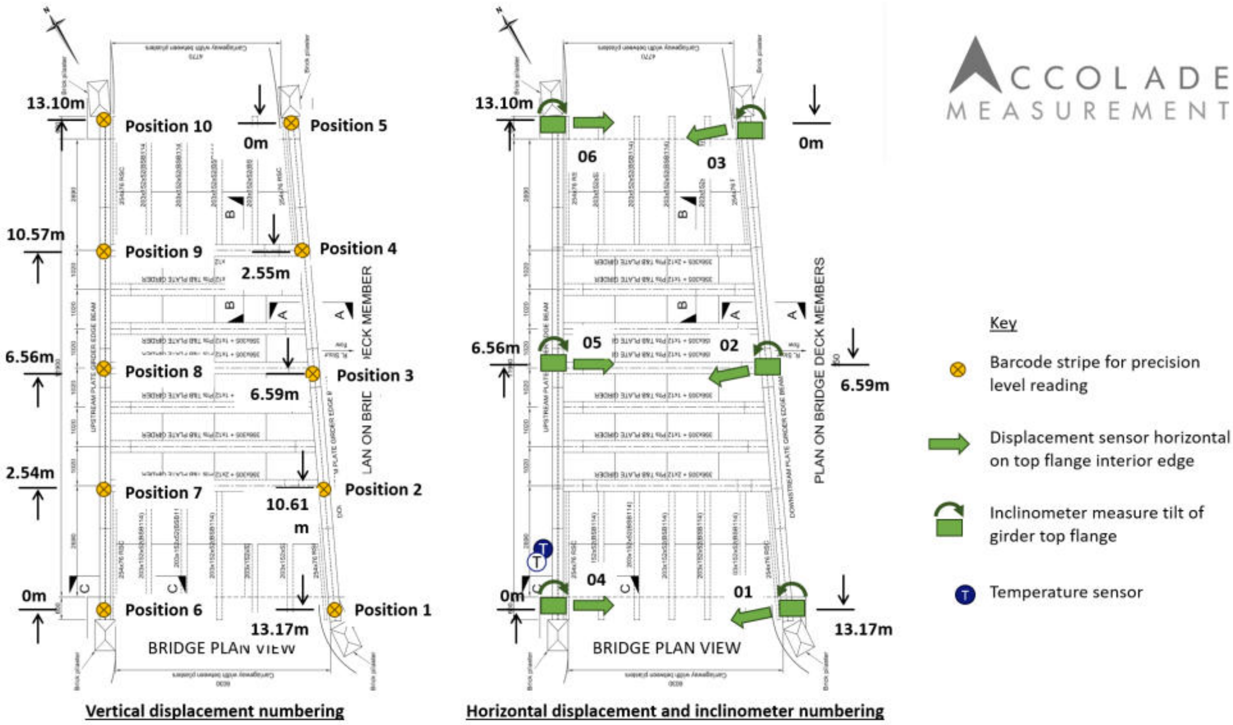


Figure 10 Sensor Layout and Numbering

6. Data & Visualisation

Three data files were generated and archived as part of this load test:

- 3384_Boxted_2025-09-10.csv – the zeroed dataset, containing unmodified outputs from all horizontal displacement sensors, inclinometers and temperature measurements.
- 3384_Boxted_2025-09-10.xlsx – modified and augmented dataset including charts and calculations.
- 3384_Boxted_Survey_2025-09-10.xlxs – optical survey data for vertical displcaements and charts generated during testing.

The modified file was used for all graphical outputs included in this report.

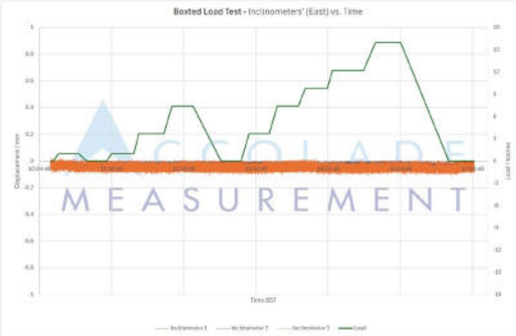
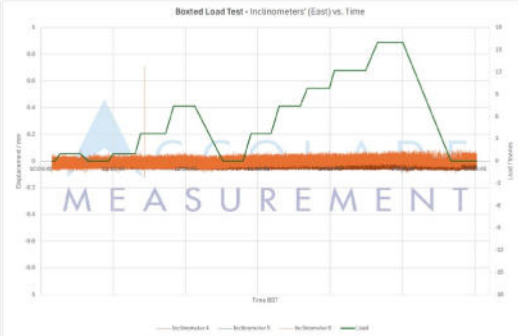
Chart Outputs

Refer to Appendix A.

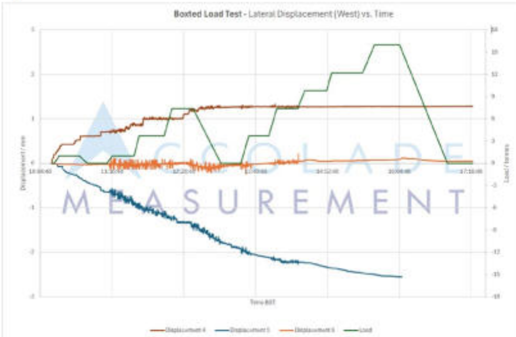
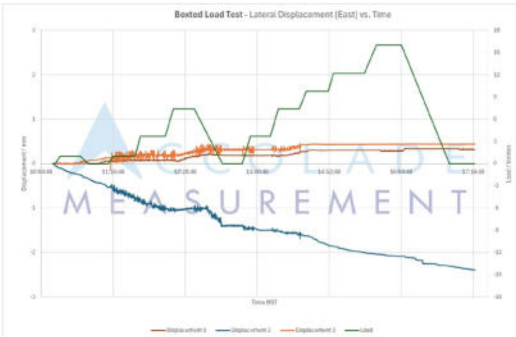
7. Commentary

Interpretation of the data is to be concluded by Essex Highways, but Accolade note the following findings. Accolade will remain contactable for any assistance needed. Images are given with the comments below, but the reader should refer to Appendix A for clearer versions of the same graphs.

1. Change in lateral incline of the girder top flange is below the repeatability of the sensing and shows no measurable response to load. These results cannot determine pass or fail for proof loading, but raise no concerns.

2. Horizontal movements of top flange are significant, reaching up to 2mm. There is no identified reason to doubt the validity of the measurements, though the results were not as expected. Fine jitters in the readings are noted on all these sensors at periods of stronger wind.
In both girders, the mid-span reading shows outward movement (negative), increasing throughout the test. As it was not directly measured, it's hard to confirm, but during the testing there was a suspicion that the movements were increasing during times of bright sunlight, and not returning when the sky clouded over. Perhaps the deck was expanding forcing the girder apart.

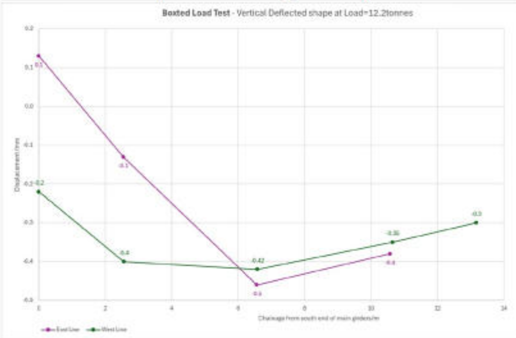



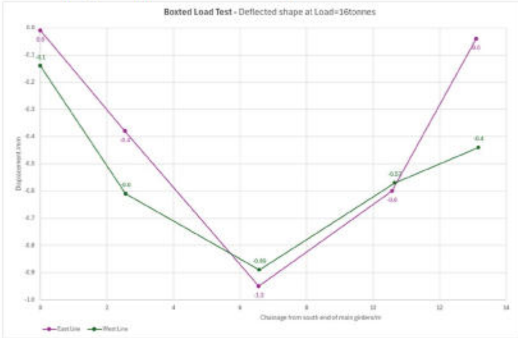
The south-west corner (displacement 4) moves inwards, perhaps as a result of forced twisting in the girder, as the mid-span widens. The south-east and north-east do similarly, to a lesser magnitude.
We recommend that these results are not considered representative of the proof load testing. These have not identified any cause for concern.

3. The bridge girders showed no detected signs of U-frame lateral torsional bucking in the test.

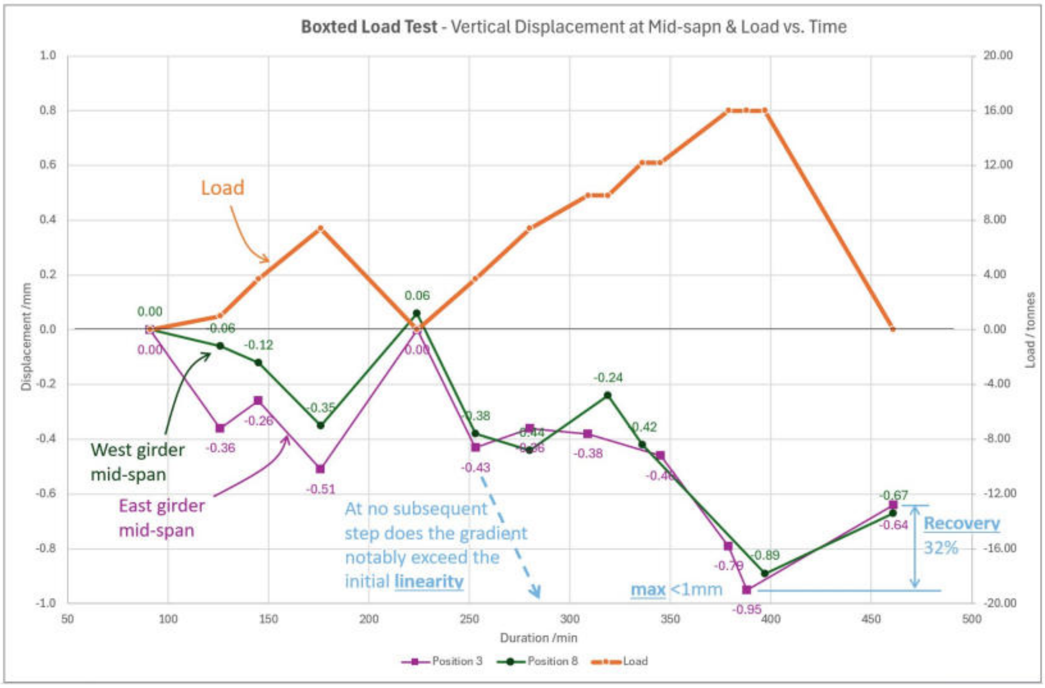
4. At loads up to and including 12.2 tonnes, the deflected shape does not wholly show the assumed behaviour, perhaps affected by some unintentional restraint or embedded/thermal stresses and small movements at the support positions confuse the results. At 16 tonnes, the

deflected shape is as might be predicted for a simply supported bridge.



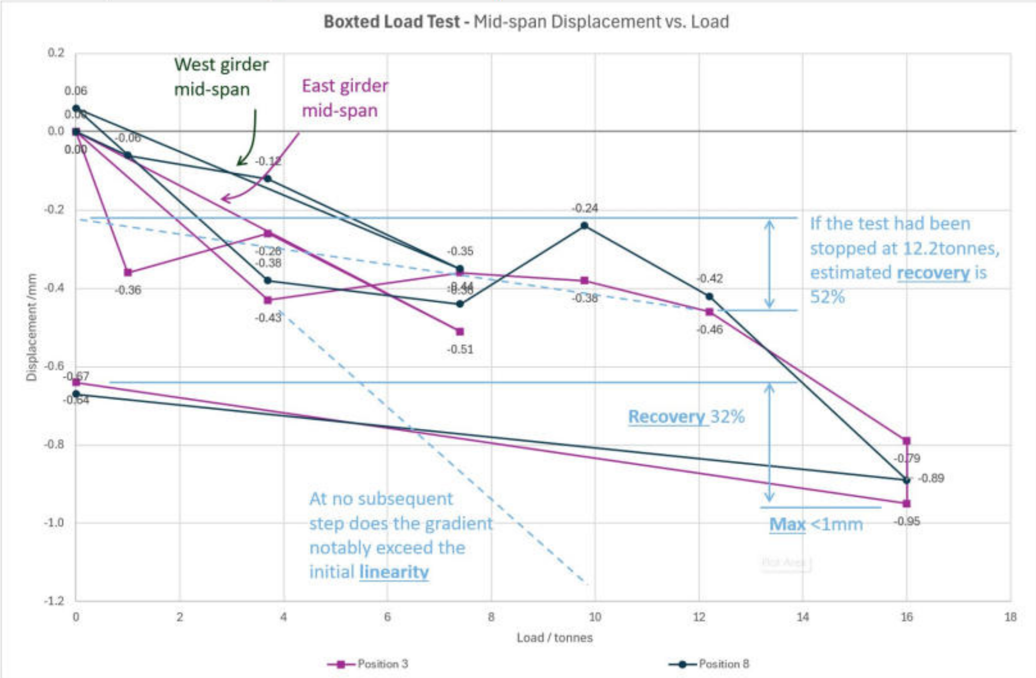


5. Vertical displacements show small movement at mid-span, similar to the modelled predictions (conducted by Essex Highways in advance of the test). There is some evidence that the bridge has a slow response to applied loads, which is normal in reinforced concrete bridges, but not so for steel bridges and hence wasn't expected here.
   Maximum movements of less than 0.5mm can be seen at the planned target load of 12.2 tonnes. At the increased upper load limit (16 tonnes) maximum movements are still no greater than 1mm.



6. Linearity in the vertical displacement is acceptable. After an initial movement at low load, thereafter at no point is a gradient seen in the displacement vs. load at greater incline. This could be attributed to the slow response of the structure to load. At the lowest load on the final cycle, the bridge has recently been exposed to a greater magnitude and hence its response is swift; but as the load continues to increase the structure lags in its response to a greater load.

However, there is no sign that the linearity criteria is breached within the test.



7. Recovery in vertical displacement did not meet the stop criteria of 90%. From the maximum load of 16tonnes, a recovery is seen of just 32%. Taking the same gradient of the unloading, applied from the measurement at 12.2tonnes, we can estimate that the recovery might have been 52%. On the basis that we can see some signs which infer a slow response of the structure to applied load, it can be reasoned that the same is true in the unloading. Perhaps a greater recovery would have been measured if additional vertical displacement measurements were taken later. (Time limited this on the testing day, and the reference pins have been removed.)

8. Results are compared to the Stop Criteria as follows:

	Stop Criteria			Results		
Measurement	Max.	Linearity	Recovery	Max.	Linearity	Recovery
General observations by eye	N/A	N/A	N/A	No noted signs of distress		
Total vertical movement	50mm	85%	90%	<1mm	Ok	Estimated 32%
Total horizontal movement	N/A	N/A	N/A	Not measured		
Girder vertical deformation	15mm	85%	90%	<1mm	Ok	Estimated 32%
Girder lateral deformation at abutments	15mm	85%	90%	<0.1°	--	--
Girder lateral deformation at mid-span total	15mm	85%	90%	<3mm*	--	--
Girder lateral deformation along length	15mm	85%	90%	<3mm*	--	--
Girder top flange tilt at abutments absolute	initial + 1 deg.	85%	90%	Initial + <0.1°	--	--
Girder top flange tilt at mid-span absolute	initial + 1 deg.	85%	90%	Initial + <0.1°	--	--
Top flange rotation at abutments	1 deg.	85%	90%	<0.1°	--	--
Top flange rotation at midspan	1 deg.	85%	90%	<0.1°	--	--
Girder top flange twist	1 deg.	85%	90%	<0.1°	--	--

Notes: * Analysis suggests this is not movement caused by water load applied.

8. Conclusion

A proof load test has been conducted on the Boxted Bridge, aiming to justify re-opening for pedestrian and cyclist traffic over a 2m width down the centre of the deck. A maximum load of 16tonnes was applied creating a bending moment approximately 422kNm shared between the two girders, with no visible signs of distress.

Fine measurement of movements recorded vertical displacement less than 1mm. Lateral displacement and incline measurements show no distress of the U-frames under applied loading.

Stop criteria were not breached for measured displacements and deformation, except the elastic recovery in vertical displacement desired of 90%. Vertical movement of the main girders recovered only an approximated 52% for loading up to 12.2 tonnes, representing the proposed ultimate limit state load when re-opened.

Evidence in the data set suggests the bridge has a time delay in response to load applied and perhaps unloading. If readings were to have been taken again at some time after the load was removed (perhaps 2 hours), it is possible that the deformation would have continued to recover closer to zero. The asset owner should consider whether this criteria is critical for permitting the bridge to be re-opened to the proposed limited traffic.

Appendix A. Graphical Displays

Selected graphical displays of the data are presented which may be of use to guide the engineer(s) responsible for analysis and interpretation.

3384 Boxted Load Test

Test Position	South Abutment
Date	10/09/2025
Survey Equipment	Leica LS15
Serial Number	712475
Calibration Date	04/09/2025
Weather	Changeable / Showers
Air Temperature	19degC
Layour Drawing?	Yes

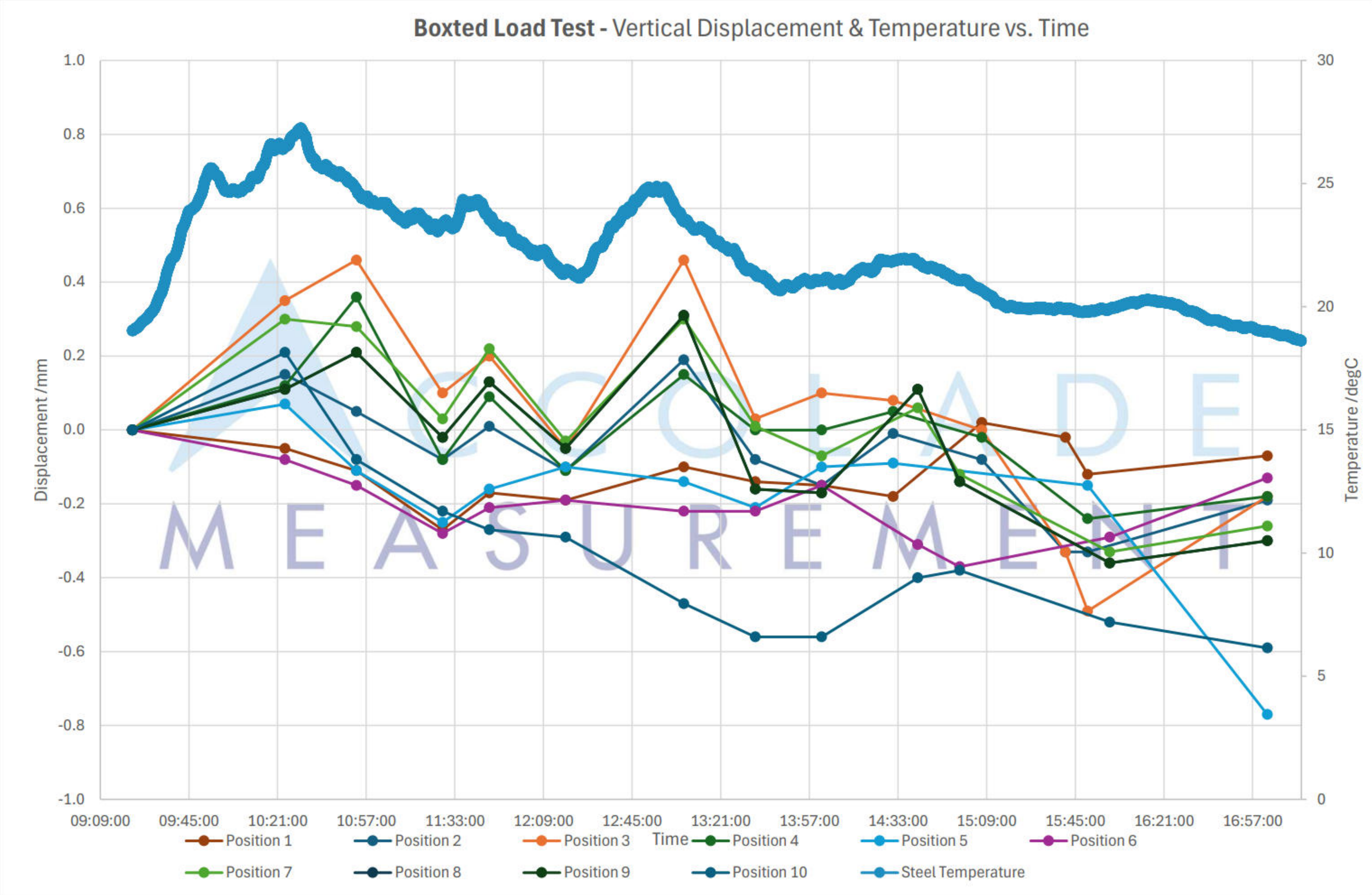
Data Input Here																
Time	**Load**	**Temperatu**	**Ref #1**	**Ref #2**	**Position #1**	**Position #2**	**Position #3**	**Position #4**	**Position #5**	**Position #6**	**Position #7**	**Position #8**	**Position #9**	**Position #10**	**Ref #3**	**Ref #4**
	/m3	**/degC**	**/m**	**/m**	**/m**	**/m**	**/m**	**/m**	**/m**	**/m**	**/m**	**/m**	**/m**	**/m**	**/m**	**/m**
10:53:00	0	24.8	1.71892	1.82081	-0.34360	-0.21476	-0.28947	-0.36333	-0.38056	0.03226	0.24478	0.32405	0.19224	0.23664	1.82588	1.44413
11:28:00	1	23.3	1.71977	1.82170	-0.34259	-0.21378	-0.28826	-0.36204	-0.37957	0.03324	0.24588	0.32496	0.19332	0.23763	1.82689	1.44531
11:47:00	3.7	23.6	1.72683	1.82872	-0.33563	-0.20681	-0.28130	-0.35515	-0.37260	0.04023	0.25275	0.33208	0.20023	0.24474	1.83370	1.45213
12:18:00	7.4	21.4	1.72677	1.82862	-0.33567	-0.20675	-0.28111	-0.35501	-0.37272	0.04015	0.25294	0.33225	0.20035	0.24470	1.83369	1.45223
13:06:00	0	23.5	1.72675	1.82863	-0.33578	-0.20707	-0.28164	-0.35529	-0.37270	0.04016	0.25259	0.33182	0.19997	0.24486	1.83370	1.45213
13:35:00	3.7	21.4	1.72670	1.82860	-0.33579	-0.20685	-0.28126	-0.35519	-0.37268	0.04011	0.25283	0.33221	0.20039	0.24490	1.83369	1.45201
14:02:00	7.4	21.1	1.72669	1.82853	-0.33579	-0.20679	-0.28134	-0.35520	-0.37280	0.04003	0.25290	0.33226	0.20039	0.24489	1.83350	1.45217
14:31:00	9.8	21.8	1.72663	1.82854	-0.33582	-0.20699	-0.28138	-0.35531	-0.37287						1.83356	
14:41:00	9.8	21.8	1.74781	1.84959						0.06131	0.27389	0.35318	0.22123	0.26585	1.85471	
14:58:00	12.2	21.1	1.74760	1.84952						0.06116	0.27386	0.35315	0.22127	0.26562	1.85450	
15:07:00	12.2	20.7	1.75808	1.85998	-0.30457	-0.17547	-0.24985	-0.32379							1.86499	
15:41:00	16	19.9	1.75793	1.85987	-0.30468	-0.17537	-0.24967								1.86489	
15:50:00	16	19.8	1.69716	1.79911	-0.36535	-0.23614	-0.31028	-0.38449	-0.40228						1.80413	
15:59:00	16	19.9	1.72394	1.82583						0.03742	0.25041	0.32996	0.19783	0.24210	1.83089	
17:03:00	0	19	1.72153	1.82346	-0.34103	-0.21191	-0.28622	-0.36018	-0.37729	0.03485	0.24793	0.32733	0.19536	0.23976	1.82851	1.44699

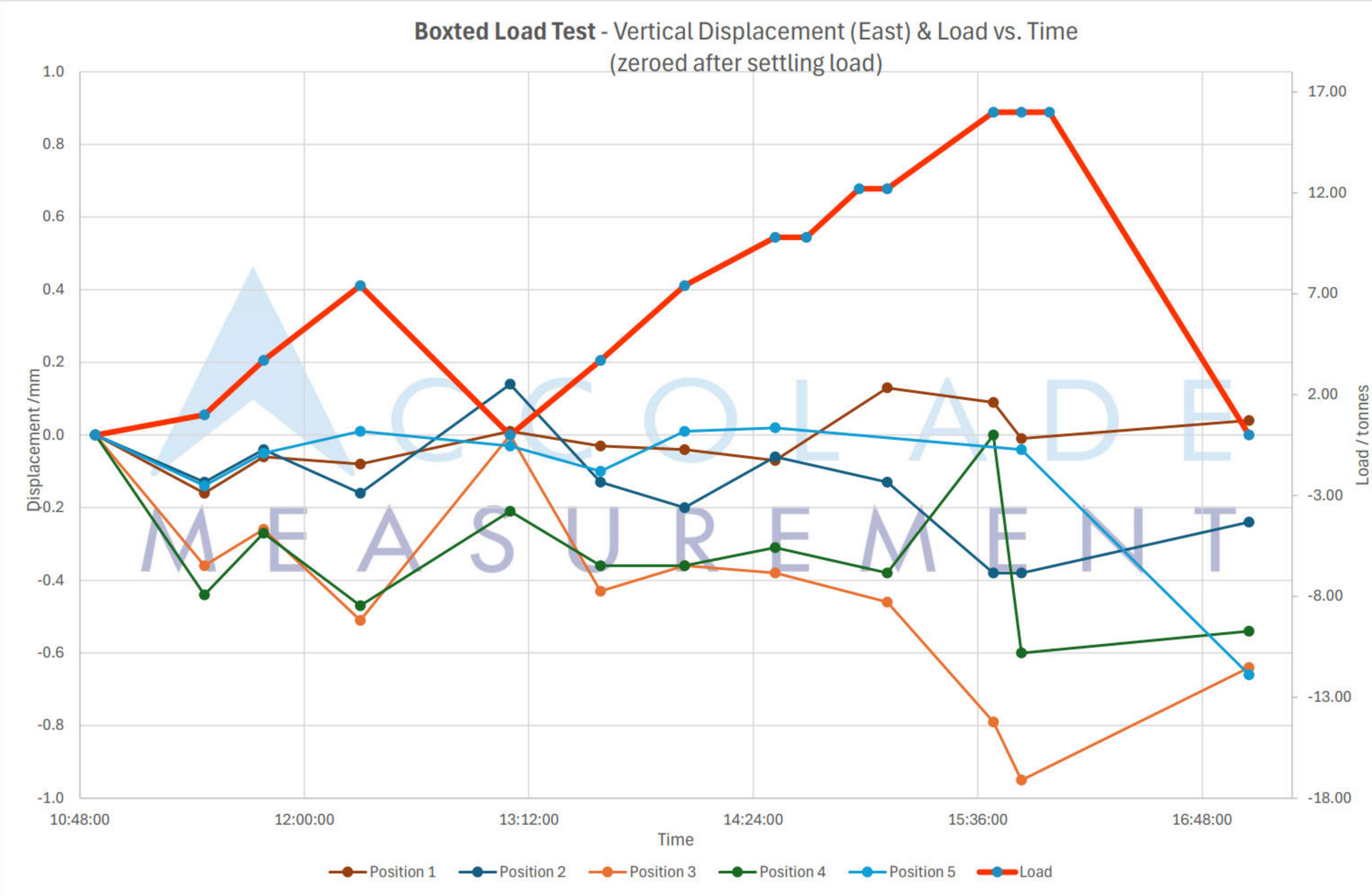
Ref 2 Δ	Initial Δ #1	Initial Δ #2	Initial Δ #3	Initial Δ #4	Initial Δ #5	Initial Δ #6	Initial Δ #7	Initial Δ #8	Initial Δ #9	Initial Δ #10	Ref 3 Δ	Ref 4 Δ
/m	/m	/m	/m	/m	/m	/m	/m	/m	/m	/m	/m	/m
0.10189	-2.06252	-1.93368	-2.00839	-2.08225	-2.09948	-1.68666	-1.47414	-1.39487	-1.52668	-1.48228	0.10696	-0.27479

Chainage (m)	0	2.54	6.56	10.57	13.1	0	2.56	6.58	10.65	13.17

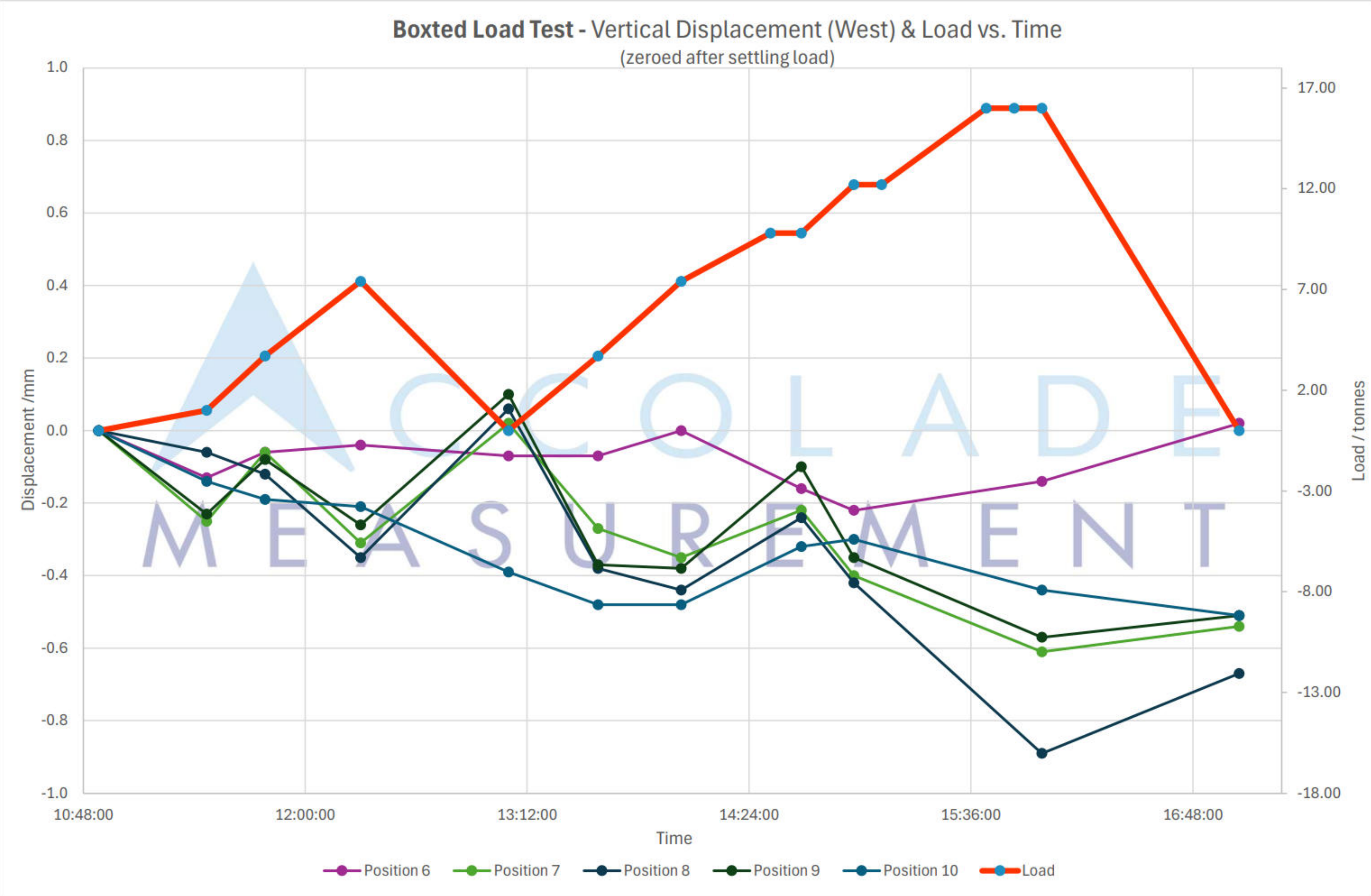
Calculation Output Here

Duration	Load	Ref #2	Settlement #1	Settlement #2	Settlement #3	Settlement #4	Settlement #5	Settlement #6	Settlement #7	Settlement #8	Settlement #9	Settlement #10	Ref #3	Ref #4	Average	Max Settleme	Differnetial
/min	/m3	/mm	/mm	/mm	/mm	/mm	/mm	/mm	/mm	/mm	/mm	/mm	/mm	/mm	/mm	/mm	/mm
91.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0
126.00	1.00	0.0	-0.2	-0.1	-0.4	-0.4	-0.1	-0.1	-0.3	-0.06	-0.23	-0.1	-0.2	-0.3	-0.2	-0.4	0.4
145.00	3.70	0.0	-0.1	0.0	-0.3	-0.3	0.0	-0.1	-0.1	-0.12	-0.08	-0.2	0.1	-0.1	-0.1	-0.3	0.2
176.00	7.40	0.0	-0.1	-0.2	-0.5	-0.5	0.0	0.0	-0.3	-0.35	-0.26	-0.2	0.0	-0.3	-0.2	-0.5	0.5
224.00	0.00	0.0	0.0	0.1	0.0	-0.2	0.0	-0.1	0.0	0.06	0.10	-0.4	0.0	-0.2	0.0	-0.4	0.5
253.00	3.70	0.0	0.0	-0.1	-0.4	-0.4	-0.1	-0.1	-0.3	-0.38	-0.37	-0.5	0.0	-0.1	-0.3	-0.5	0.5
280.00	7.40	0.1	0.0	-0.2	-0.4	-0.4	0.0	0.0	-0.3	-0.44	-0.38	-0.5	0.2	-0.3	-0.3	-0.5	0.5
309.00	9.80	0.0	-0.1	-0.1	-0.4	-0.3	0.0	#N/A	#N/A	#N/A	#N/A	#N/A	0.0		#N/A	#N/A	#N/A
319.00	9.80	0.1	#N/A	#N/A	#N/A	#N/A	#N/A	-0.2	-0.2	-0.24	-0.10	-0.3	0.1		#N/A	#N/A	#N/A
336.00	12.20	0.0	#N/A	#N/A	#N/A	#N/A	#N/A	-0.2	-0.4	-0.42	-0.35	-0.3	0.1		#N/A	#N/A	#N/A
345.00	12.20	0.0	0.1	-0.1	-0.5	-0.4	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.1		#N/A	#N/A	#N/A
379.00	16.00	0.0	0.1	-0.4	-0.8		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.0				
388.00	16.00	-0.1	0.0	-0.4	-1.0	-0.6	0.0	#N/A	#N/A	#N/A	#N/A	#N/A	0.0		#N/A	#N/A	#N/A
397.00	16.00	0.0	#N/A	#N/A	#N/A	#N/A	#N/A	-0.1	-0.6	-0.89	-0.57	-0.4	0.0		#N/A	#N/A	#N/A
461.00	0.00	0.0	0.0	-0.2	-0.6	-0.5	-0.7	0.0	-0.5	-0.67	-0.51	-0.5	0.0	-0.3	-0.4	-0.7	0.7

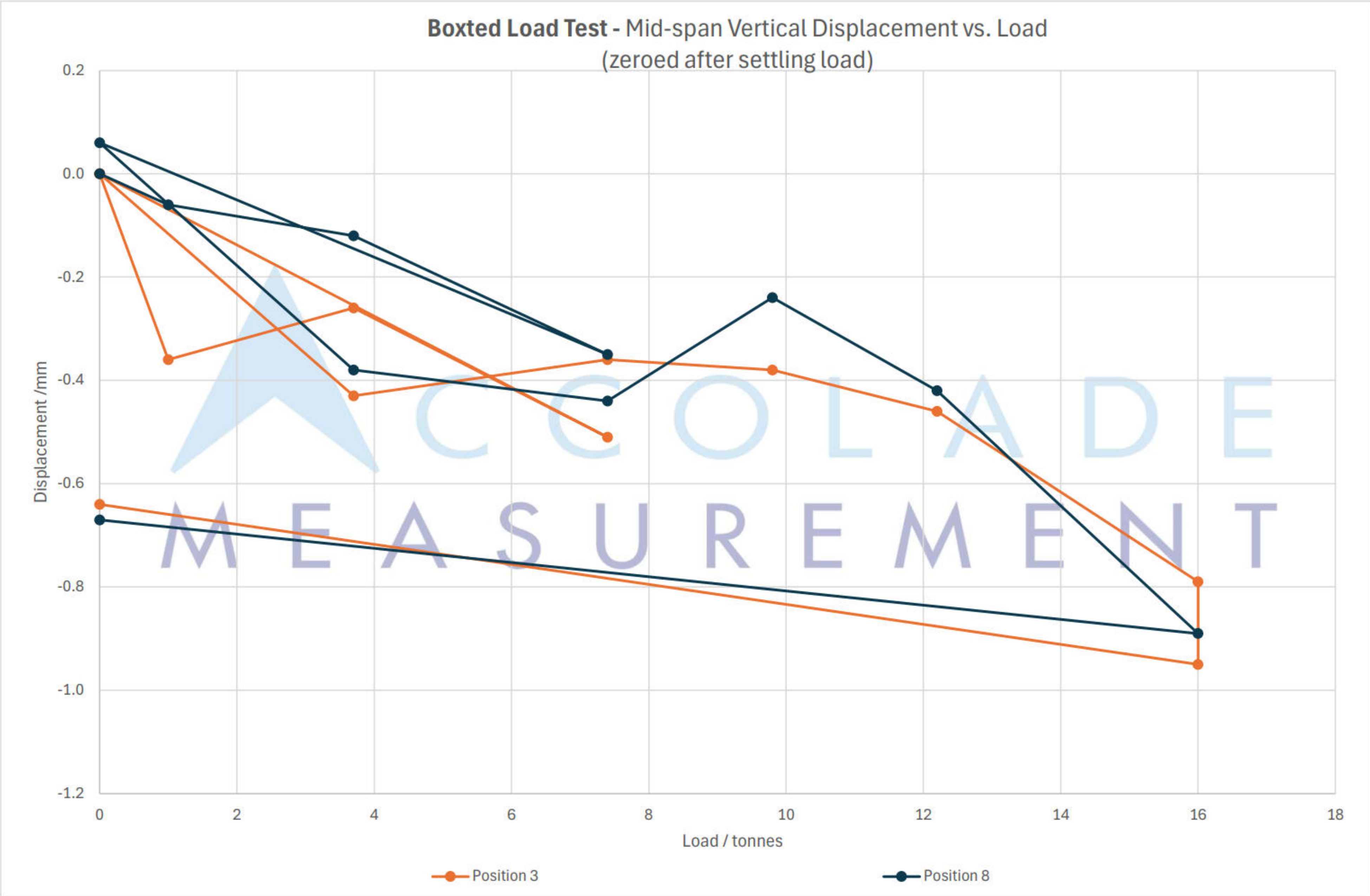

Boxted Load Test - Vertical Displacement & Temperature vs. Time
Displacement /mm
Temperature /degC
Time
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
30
25
20
15
10
5
0
09:09:00
09:45:00
10:21:00
10:57:00
11:33:00
12:09:00
12:45:00
13:21:00
13:57:00
14:33:00
15:09:00
15:45:00
16:21:00
16:57:00
Position 1
Position 2
Position 3
Position 4
Position 5
Position 6
Position 7
Position 8
Position 9
Position 10
Steel Temperature
ACCOLADE MEASUREMENT

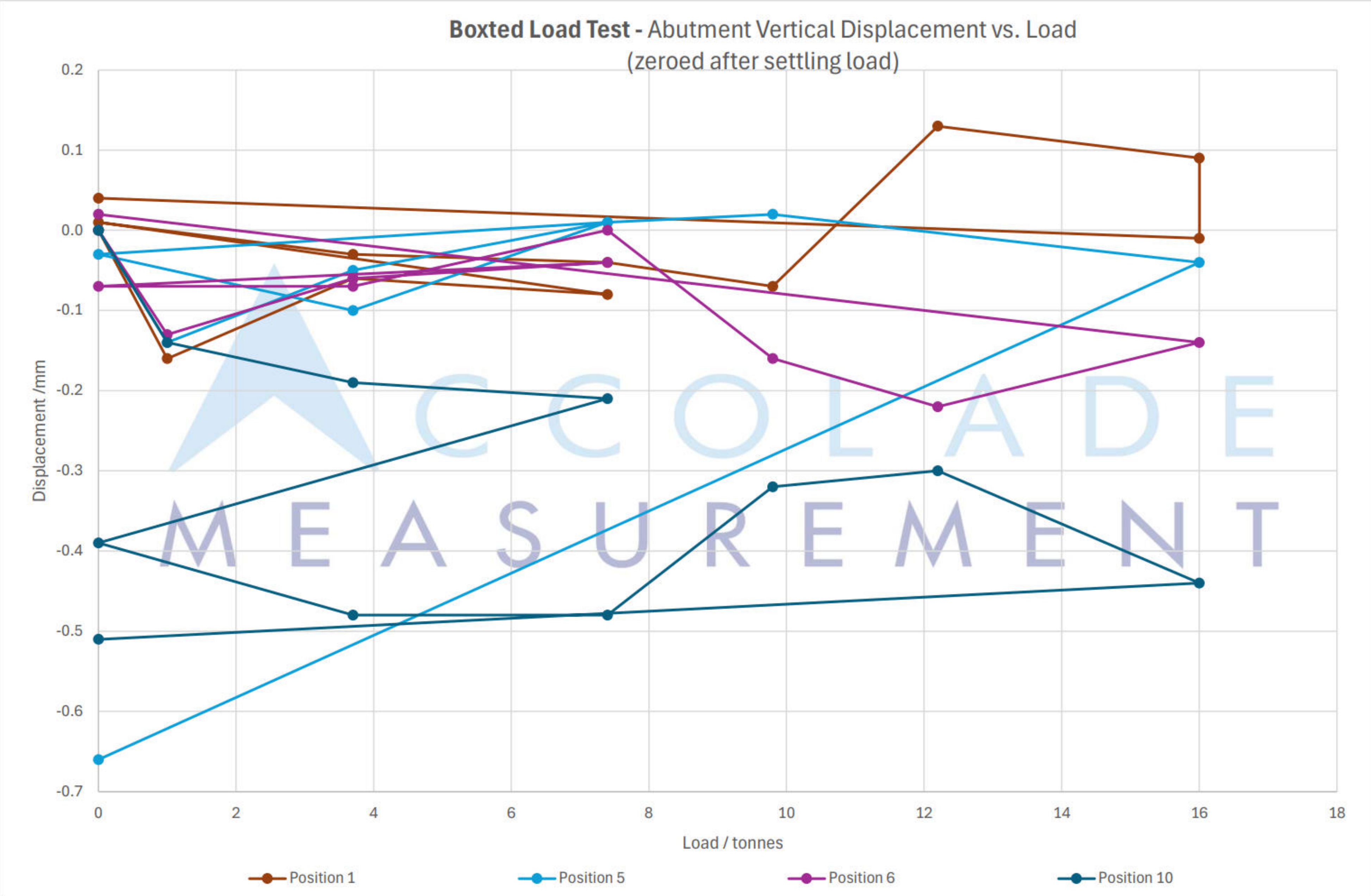


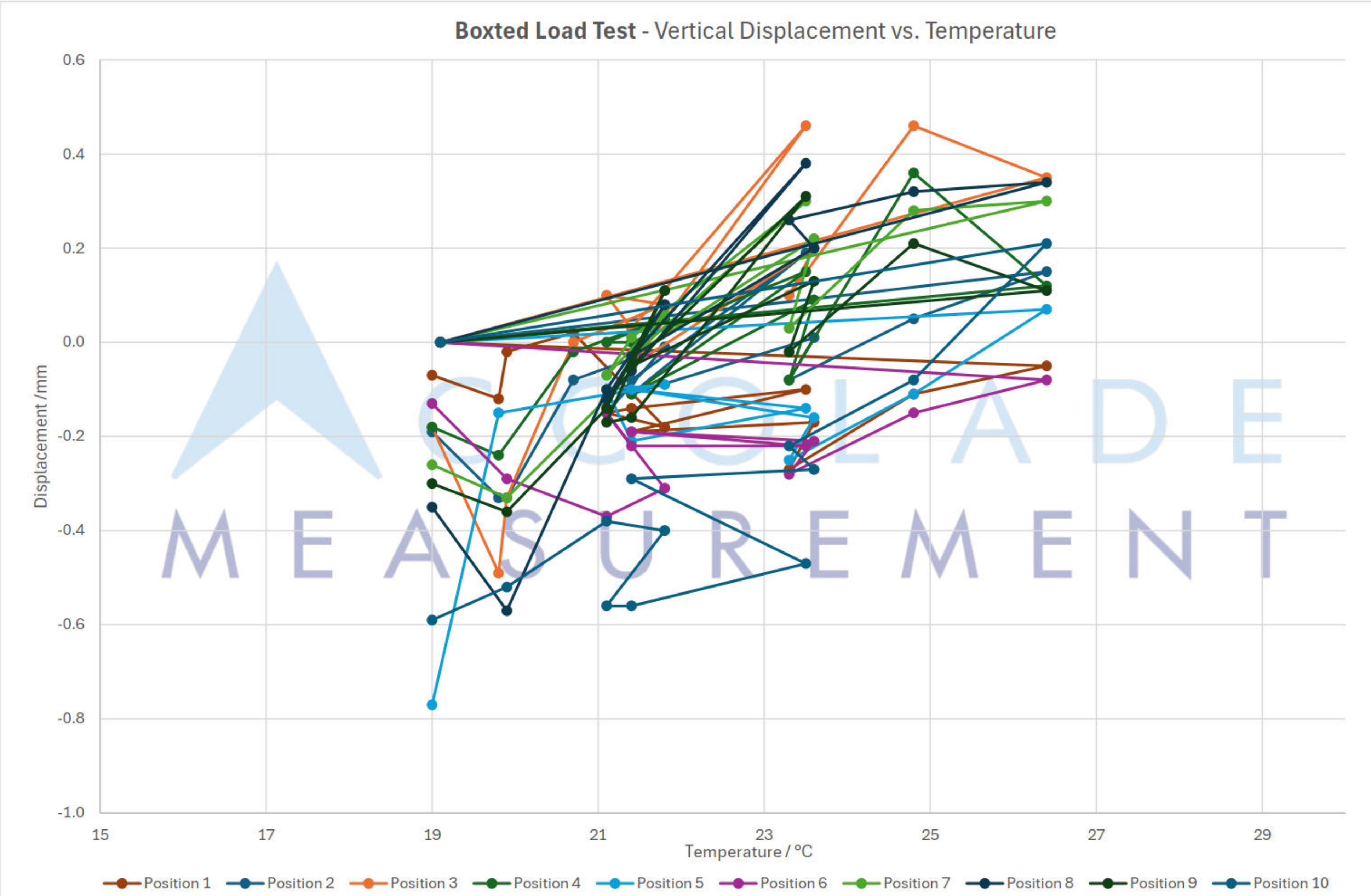
Boxted Load Test - Vertical Displacement (East) & Load vs. Time
(zeroed after settling load)
Displacement /mm
Load / tonnes
Time
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
17.00
12.00
7.00
2.00
-3.00
-8.00
-13.00
-18.00
10:48:00
12:00:00
13:12:00
14:24:00
15:36:00
16:48:00
Position 1
Position 2
Position 3
Position 4
Position 5
Load
ACCOLADE MEASUREMENT



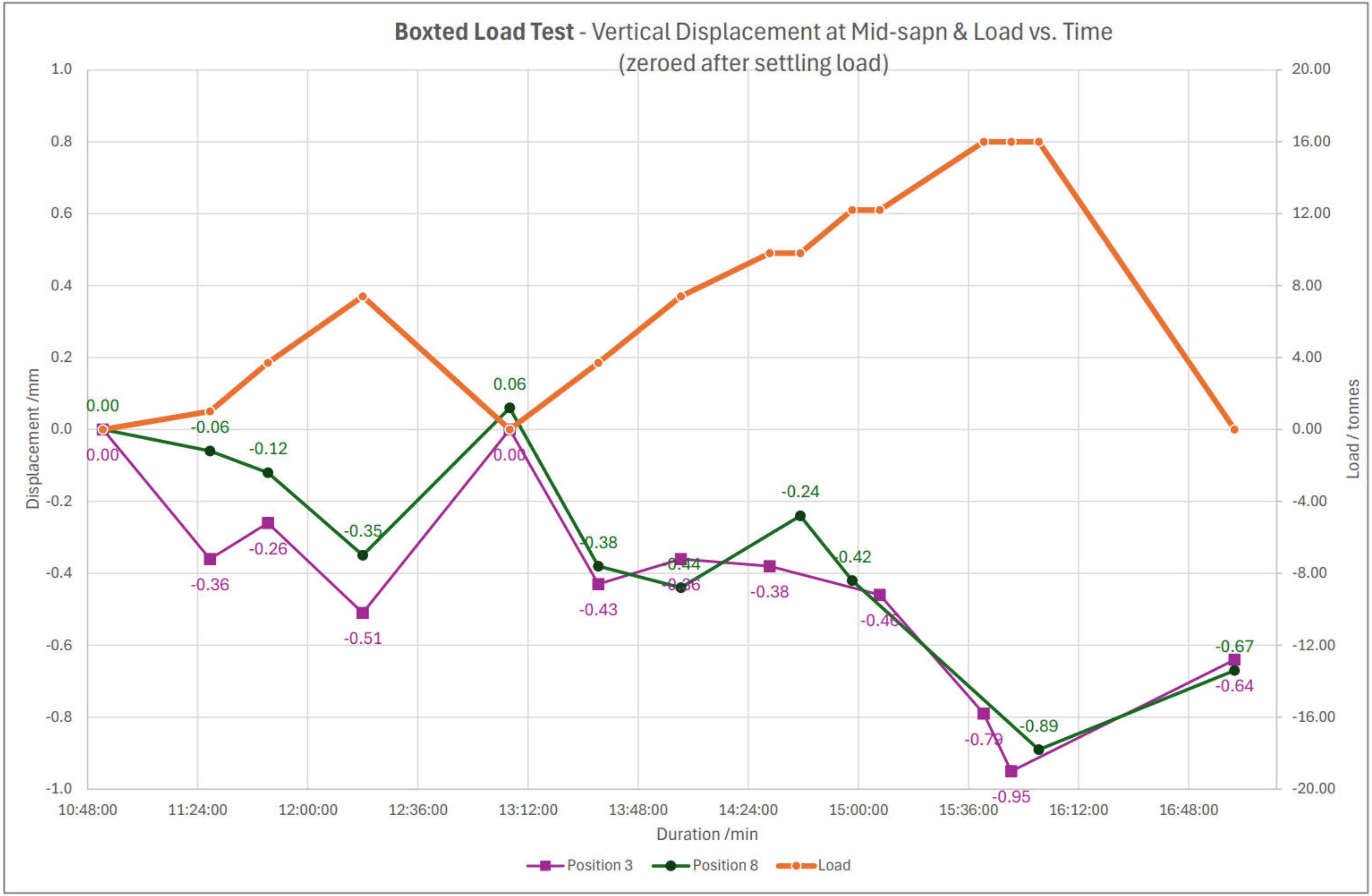
Boxted Load Test - Vertical Displacement (West) & Load vs. Time
(zeroed after settling load)
Displacement /mm
Load / tonnes
Time
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
17.00
12.00
7.00
2.00
-3.00
-8.00
-13.00
-18.00
10:48:00
12:00:00
13:12:00
14:24:00
15:36:00
16:48:00
Position 6
Position 7
Position 8
Position 9
Position 10
Load
ACCOLADE MEASUREMENT


Boxted Load Test - Mid-span Vertical Displacement vs. Load
(zeroed after settling load)
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
Displacement /mm
0
2
4
6
8
10
12
14
16
18
Load / tonnes
Position 3
Position 8
ACCOLADE MEASUREMENT

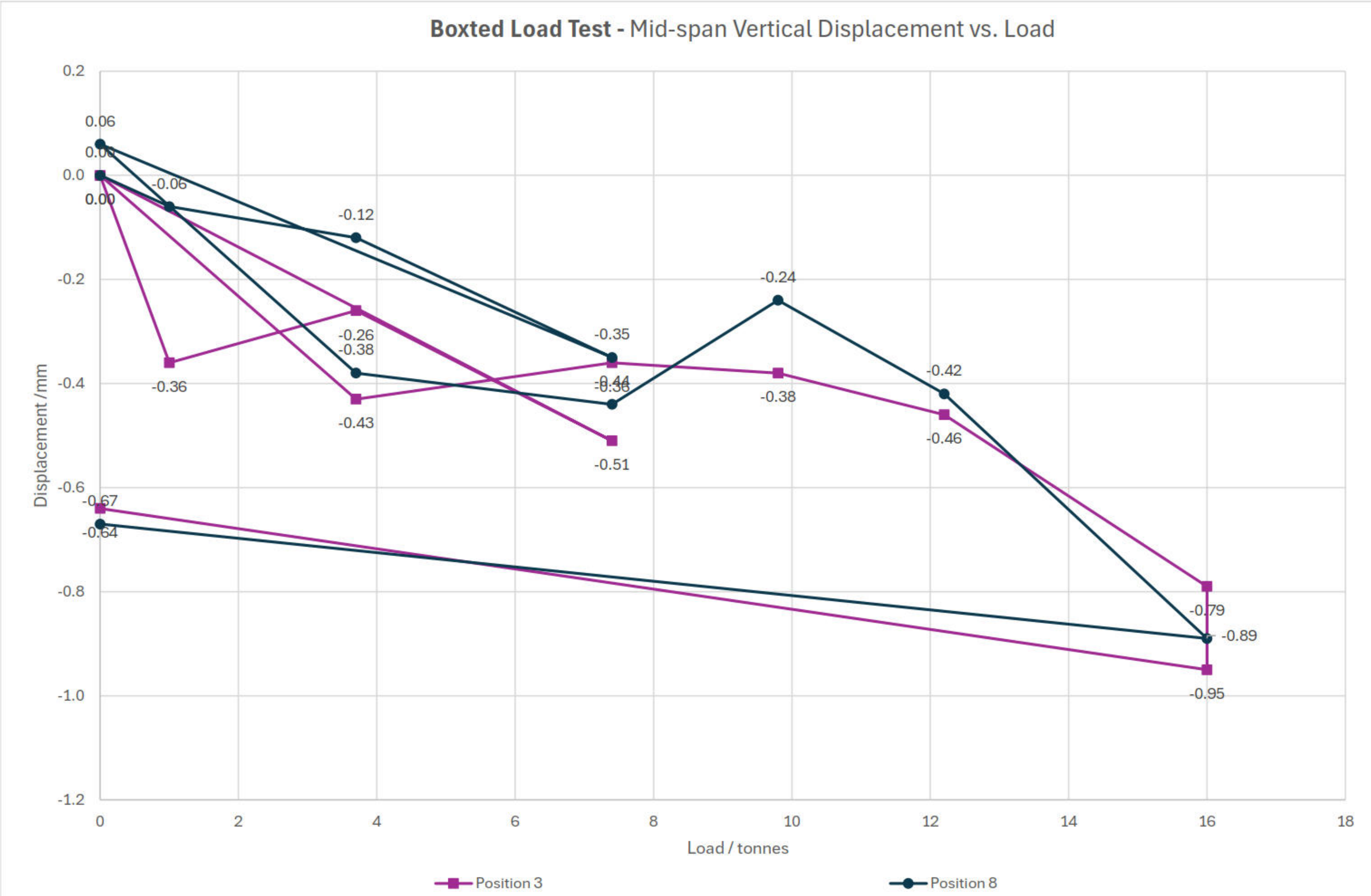

Boxted Load Test - Abutment Vertical Displacement vs. Load
(zeroed after settling load)
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
Displacement /mm
0
2
4
6
8
10
12
14
16
18
Load / tonnes
Position 1
Position 5
Position 6
Position 10
ACCOLADE MEASUREMENT



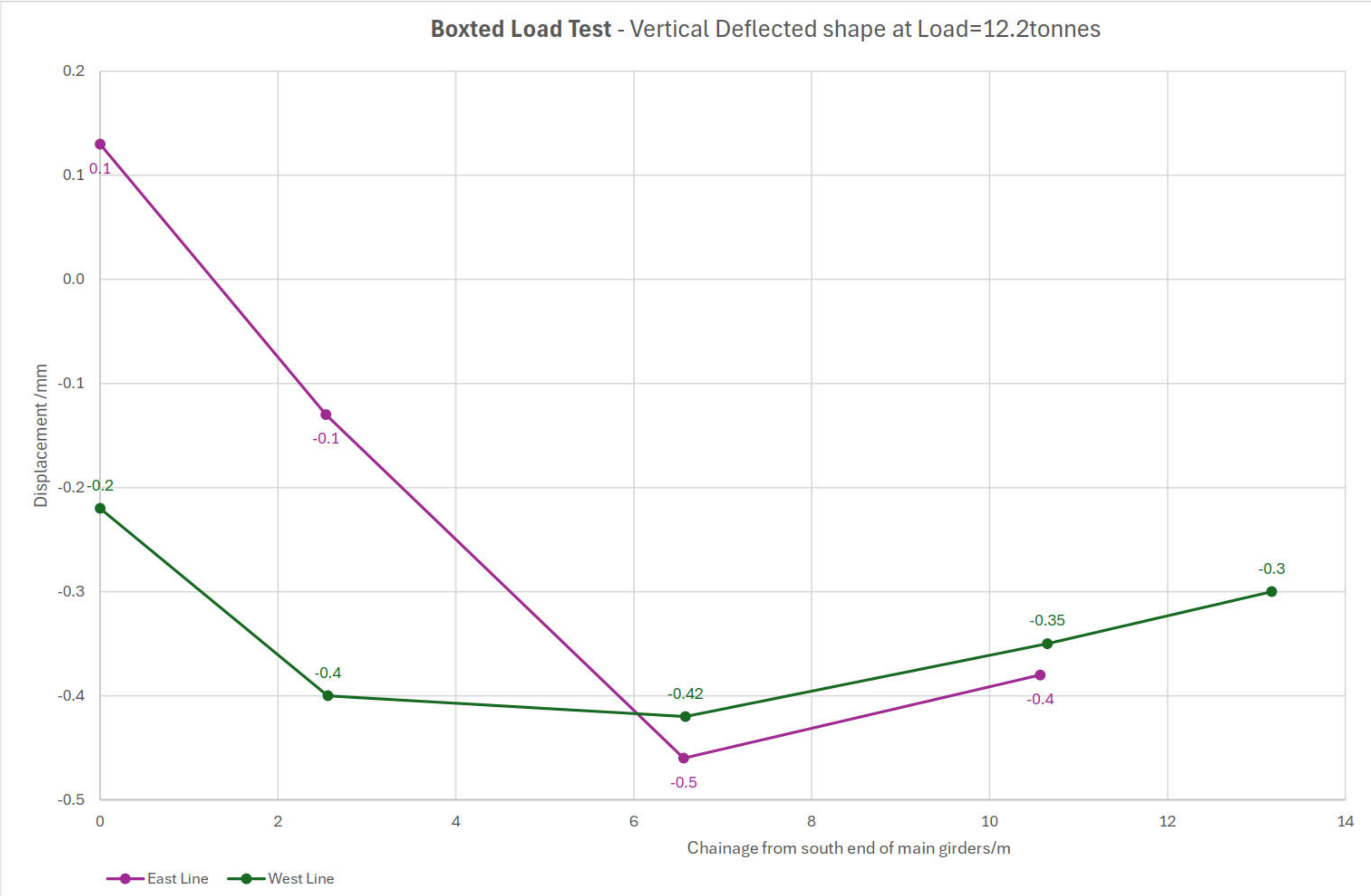
Boxted Load Test - Vertical Displacement vs. Temperature
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
Displacement /mm
15
17
19
21
23
25
27
29
Temperature / °C
Position 1
Position 2
Position 3
Position 4
Position 5
Position 6
Position 7
Position 8
Position 9
Position 10
ACCOLADE MEASUREMENT



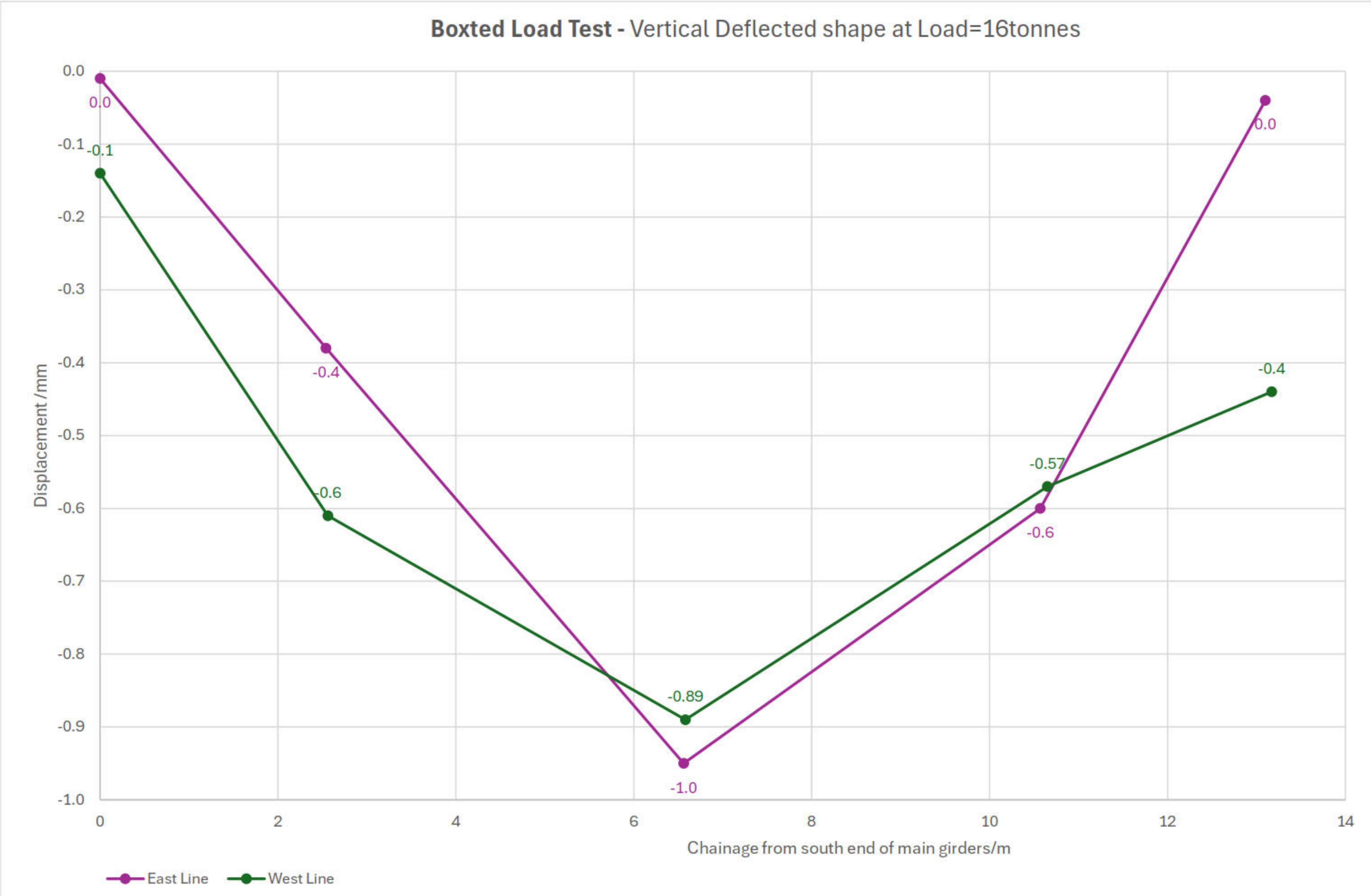
Boxted Load Test - Vertical Displacement at Mid-sapn & Load vs. Time
(zeroed after settling load)
Displacement /mm
Load / tonnes
Duration /min
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
20.00
16.00
12.00
8.00
4.00
0.00
-4.00
-8.00
-12.00
-16.00
-20.00
10:48:00
11:24:00
12:00:00
12:36:00
13:12:00
13:48:00
14:24:00
15:00:00
15:36:00
16:12:00
16:48:00
0.00
-0.06
-0.12
-0.35
0.06
-0.38
-0.44
-0.24
-0.42
-0.89
-0.67
0.00
-0.36
-0.26
-0.51
0.00
-0.43
-0.36
-0.38
-0.46
-0.79
-0.95
-0.64
Position 3
Position 8
Load

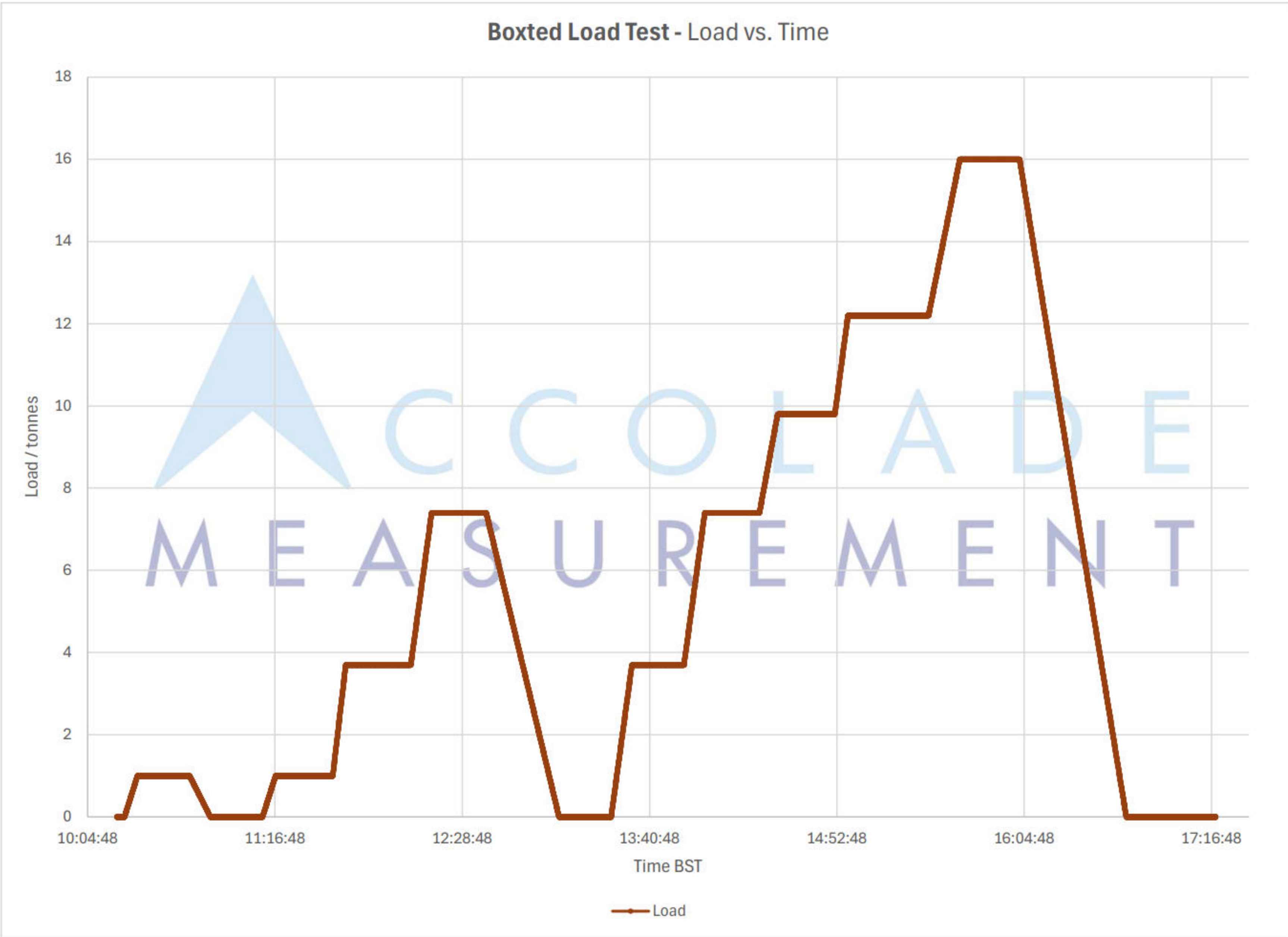


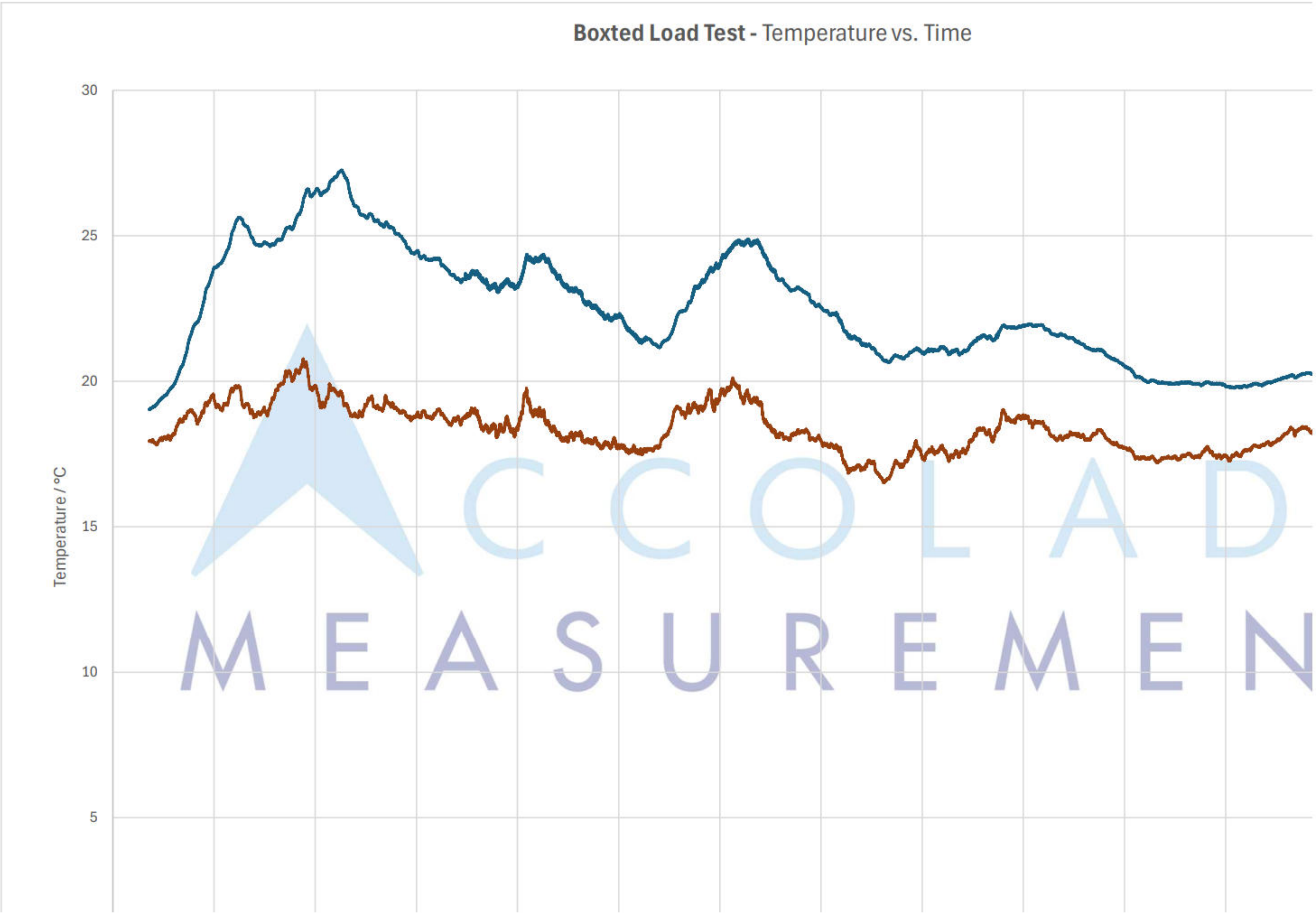
Boxted Load Test - Mid-span Vertical Displacement vs. Load
Displacement /mm
Load / tonnes
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
0
2
4
6
8
10
12
14
16
18
0.06
0.00
-0.06
-0.12
-0.24
-0.26
-0.38
-0.35
-0.36
-0.43
-0.38
-0.42
-0.46
-0.51
-0.67
-0.64
-0.79
-0.89
-0.95
Position 3
Position 8



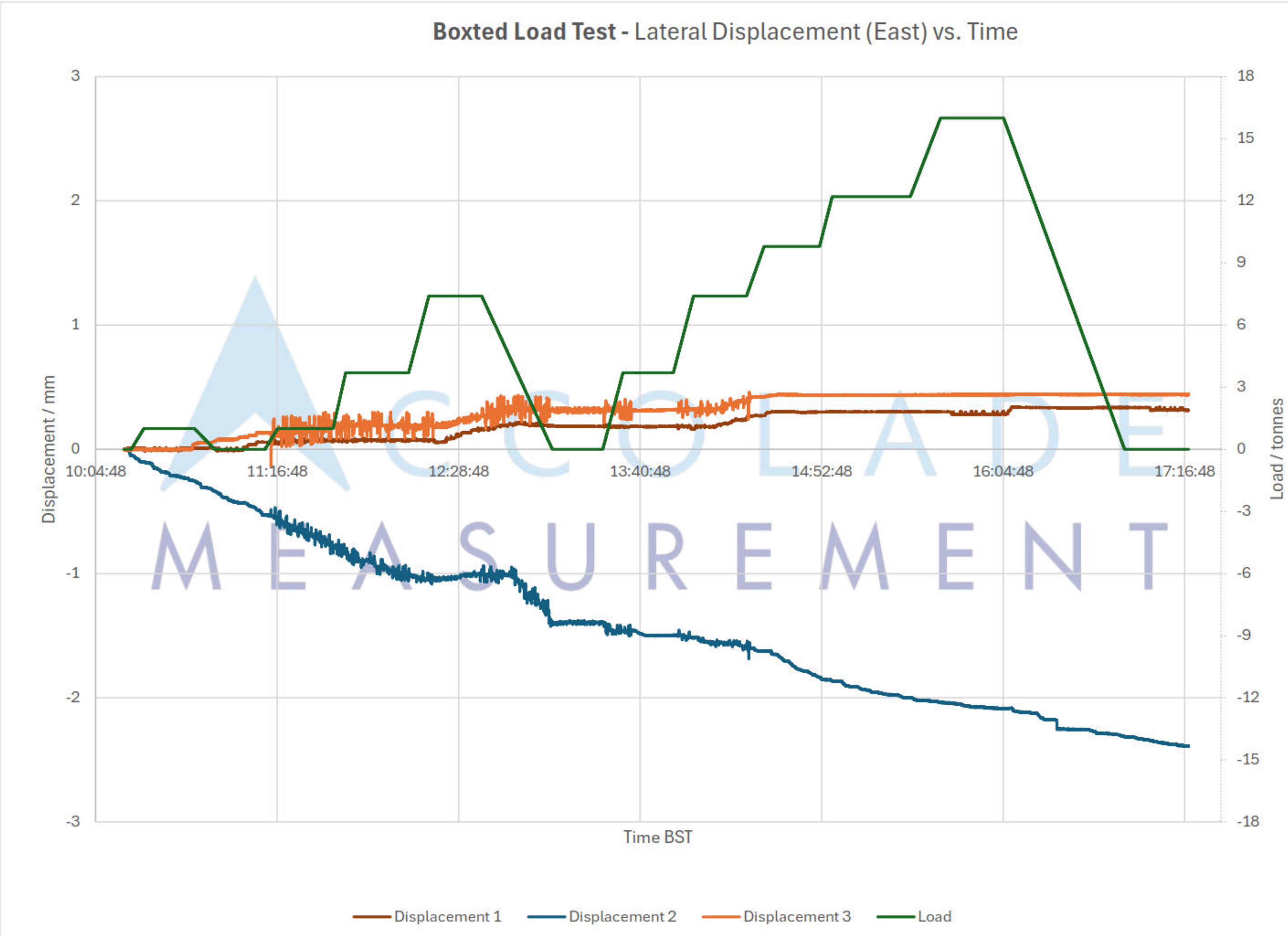
Boxted Load Test - Vertical Deflected shape at Load=12.2tonnes
Displacement /mm
Chainage from south end of main girders/m
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
0
2
4
6
8
10
12
14
0.1
-0.1
-0.2
-0.4
-0.42
-0.5
-0.4
-0.35
-0.3
East Line
West Line


Boxted Load Test - Vertical Deflected shape at Load=16tonnes
Displacement /mm
Chainage from south end of main girders/m
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
0
2
4
6
8
10
12
14
0.0
-0.1
-0.4
-0.6
-0.89
-1.0
-0.57
-0.6
0.0
-0.4
East Line
West Line

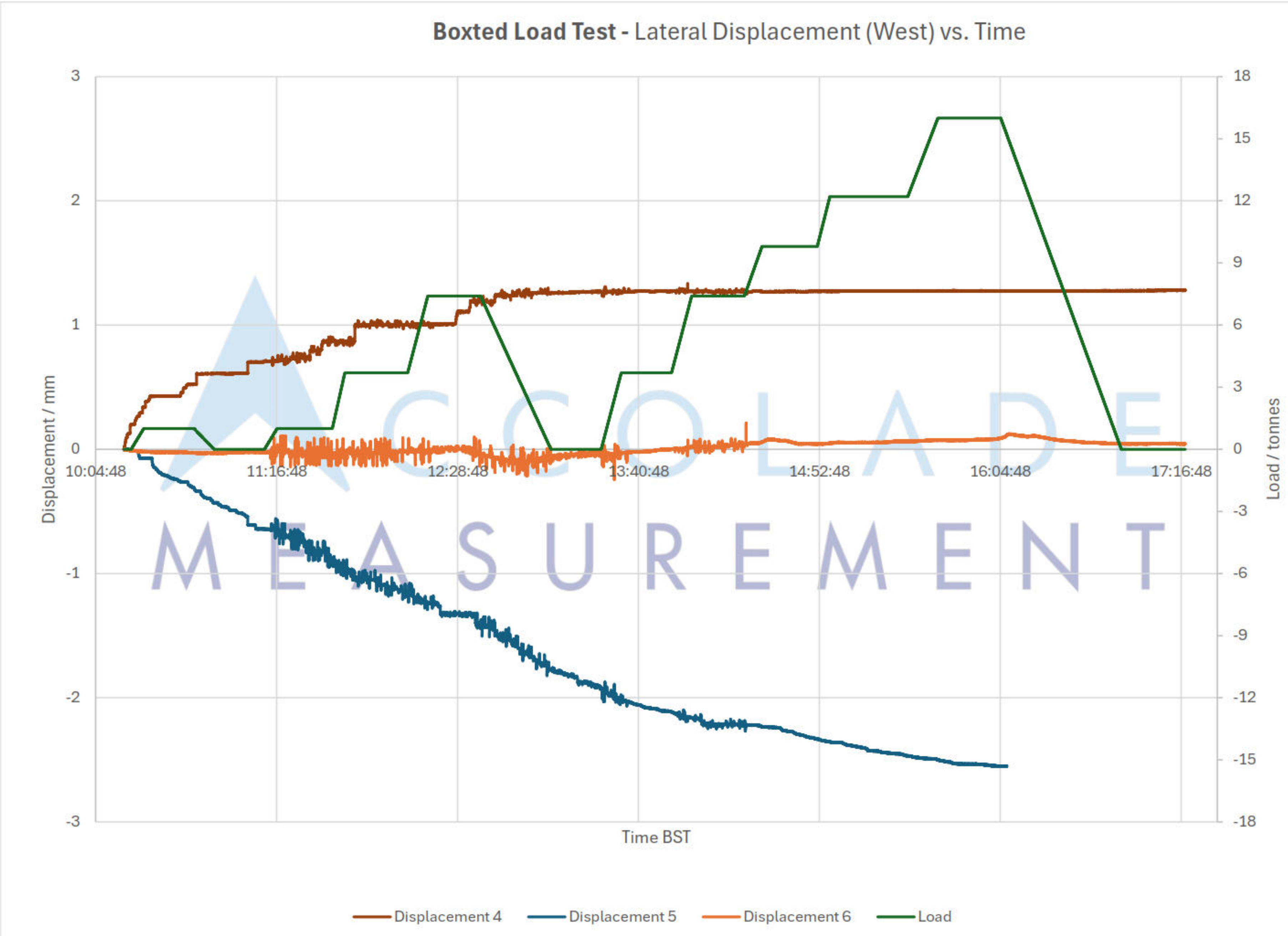

Boxted Load Test - Load vs. Time
18
16
14
12
10
8
6
4
2
0
Load / tonnes
10:04:48
11:16:48
12:28:48
13:40:48
14:52:48
16:04:48
17:16:48
Time BST
Load
ACCOLADE MEASUREMENT

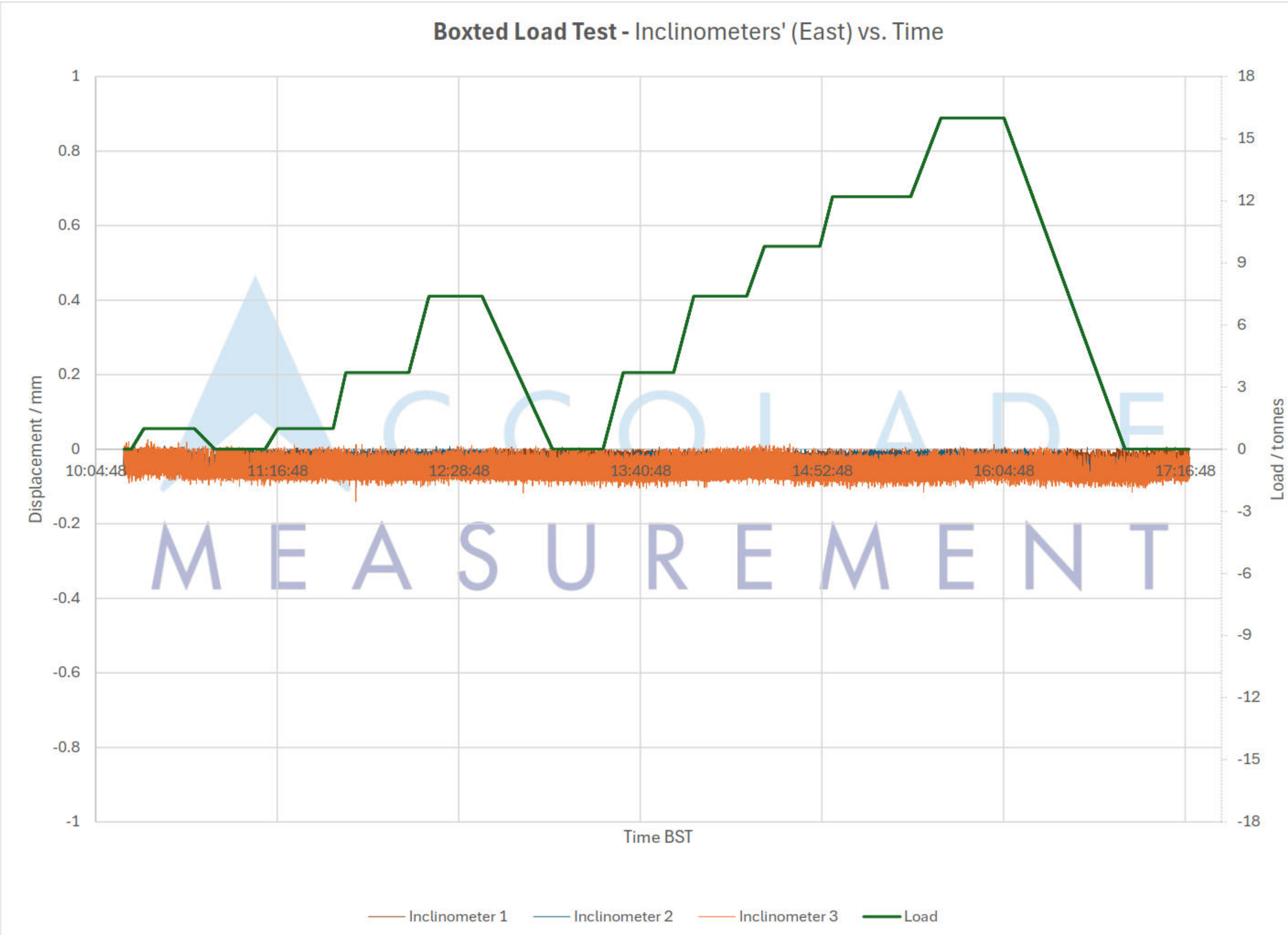


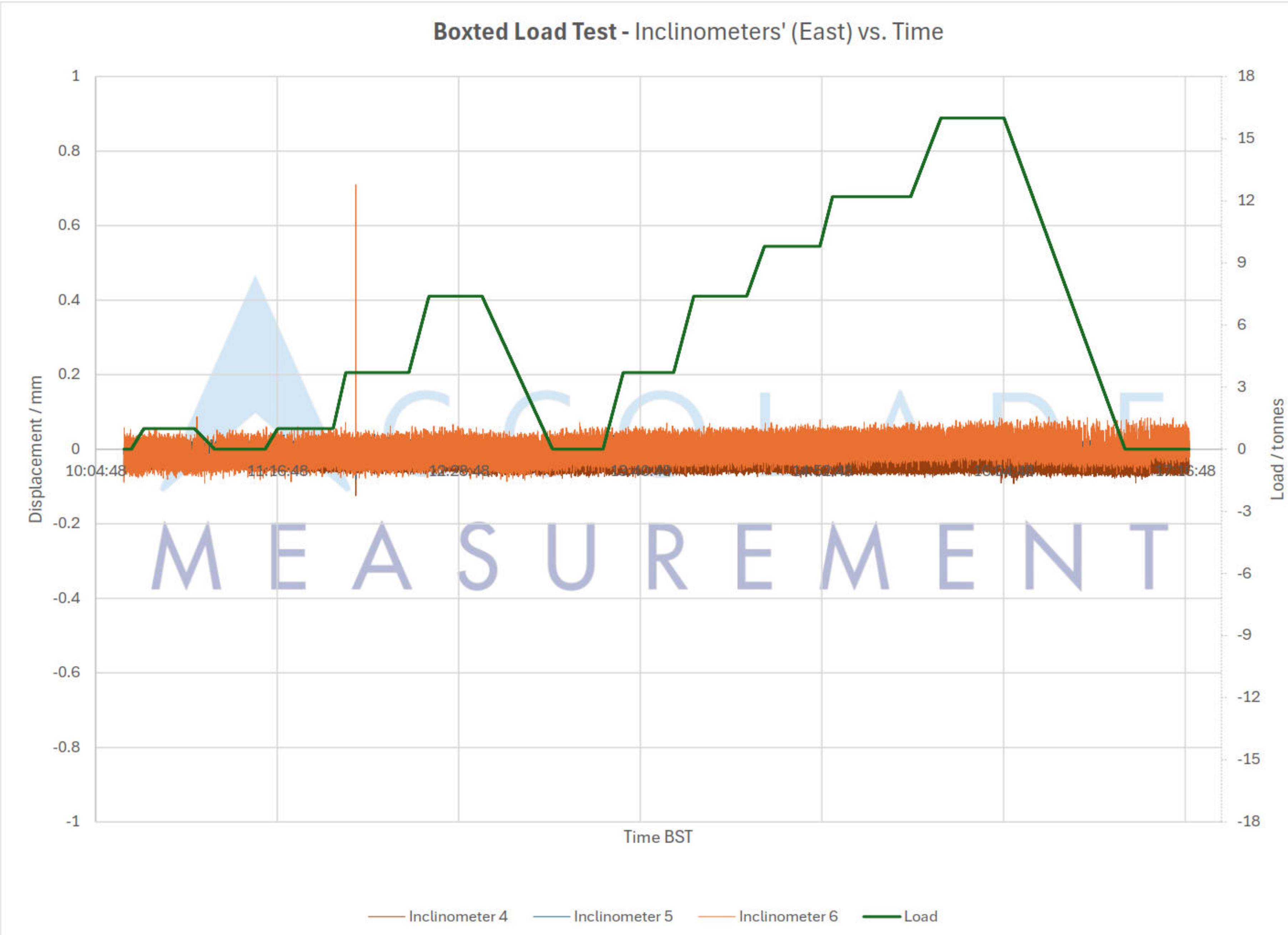
Boxted Load Test - Temperature vs. Time
30
25
20
15
10
5
Temperature / °C



Boxted Load Test - Lateral Displacement (East) vs. Time
Displacement / mm
Load / tonnes
Time BST
3
2
1
0
-1
-2
-3
18
15
12
9
6
3
0
-3
-6
-9
-12
-15
-18
10:04:48
11:16:48
12:28:48
13:40:48
14:52:48
16:04:48
17:16:48
Displacement 1
Displacement 2
Displacement 3
Load
ACCOLADE
MEASUREMENT


Boxted Load Test - Lateral Displacement (West) vs. Time
Displacement / mm
Load / tonnes
Time BST
3
2
1
0
-1
-2
-3
18
15
12
9
6
3
0
-3
-6
-9
-12
-15
-18
10:04:48
11:16:48
12:28:48
13:40:48
14:52:48
16:04:48
17:16:48
Displacement 4
Displacement 5
Displacement 6
Load
ACCOLADE MEASUREMENT


Boxted Load Test - Inclinometers' (East) vs. Time
Displacement / mm
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Load / tonnes
18
15
12
9
6
3
0
-3
-6
-9
-12
-15
-18
10:04:48
11:16:48
12:28:48
13:40:48
14:52:48
16:04:48
17:16:48
Time BST
Inclinometer 1
Inclinometer 2
Inclinometer 3
Load
ACCOLADE MEASUREMENT



Boxted Load Test - Inclinometers' (East) vs. Time
Displacement / mm
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Load / tonnes
18
15
12
9
6
3
0
-3
-6
-9
-12
-15
-18
10:04:48
11:16:48
12:28:48
Time BST
Inclinometer 4
Inclinometer 5
Inclinometer 6
Load

Appendix B. Calibration details

Records for calibration of measurement devices used in the test.

SCCS
part of Hexagon

SCCS Survey Equipment Ltd
Alpha House
Alpha Drive
Eaton Socon
Cambridgeshire
PE19 8JJ

T: 01480 404888
E: repairs.geo@sccssurvey.co.uk

Certificate of Conformity

Date of Issue: 04/09/2025

Equipment: Leica LS15 0.3mm Digital Level

Serial No. 712475

Next Conformity Check Date: 03/09/2026

Certificate No.
0000048987

Issued to:
SCCS Hire Equipment

Conformity Procedure:

This is to certify that the equipment detailed herein has been inspected and unless otherwise stated conforms in all respects to the manufacturer's original specification/workshop instructions.

Notes:

[redacted]

7 Swan Business Centre
Osier Way
Buckingham MK18 1TB
Tel: 01280 817304
Fax: 01280 817185
Email; sales@bellflowsystems.co.uk
Web; www.bellflowsystems.co.uk

BELL Flow Systems

Institute of Measurement and Control COMPANION COMPANY

Certificate of Calibration

Issued by Bell Flow Systems Ltd

Customer	Accolade Measurement Ltd	**Manufacturer**	VuAqua
Customer Ref		**Model**	WPI-SDC-65
Certificate No	WR1231	**Serial Number**	18 024605
Date Issued	20/11/2024	**Condition**	Used / Clean
Calibrated By	[redacted]	**K-factor (PPL)**	N/A
Procedure	CAL-WATER-5-M (5 Point Water)	**Flow Range**	1.6 m^3/hr - 79 m^3/hr

Calibration Method

The unit under test (UUT) was installed horizontally in the calibration rig and was calibrated using a comparison method against a reference flow meter (REF) which is traceable to National Standards.

Calibration Rig Used

Water Rig 2; MID-2 Electromagnetic Flowmeter, Serial 1402-230, 3.6 to 1200LPM, 1cPs, ambient, 20psi

Observed Results

Actual Flow (REF) M^3	Measured Flow (UUT) M^3	Frequency Hz	Meter K-factor (Actual PPL)	Error (+/- %)
5.10	5.19	N/A	N/A	1.76
1.96	1.91	N/A	N/A	-2.55
2.04	2.12	N/A	N/A	3.92
2.00	2.07	N/A	N/A	3.50
1.98	1.95	N/A	N/A	-1.52
	Average			1.02

Calibration Certificate Issued by;

[redacted]

Signature; [redacted]

Uncertainty; the uncertainty of the flow measurement under laboratory conditions is +/-1.0%.
This certificate is issued by Bell Flow Systems Ltd and confirms the findings of a calibration test carried out on the referenced calibration rig in our Calibration Laboratory which is operated to ISO 17025 standards (certification pending).

Appendix B. Monitoring Report

<u>**Monitoring Report (2661/M1)**</u>

Site: **Boxted Bridge**

Wick Road/Lower Farm Road/Sky Hall Hill

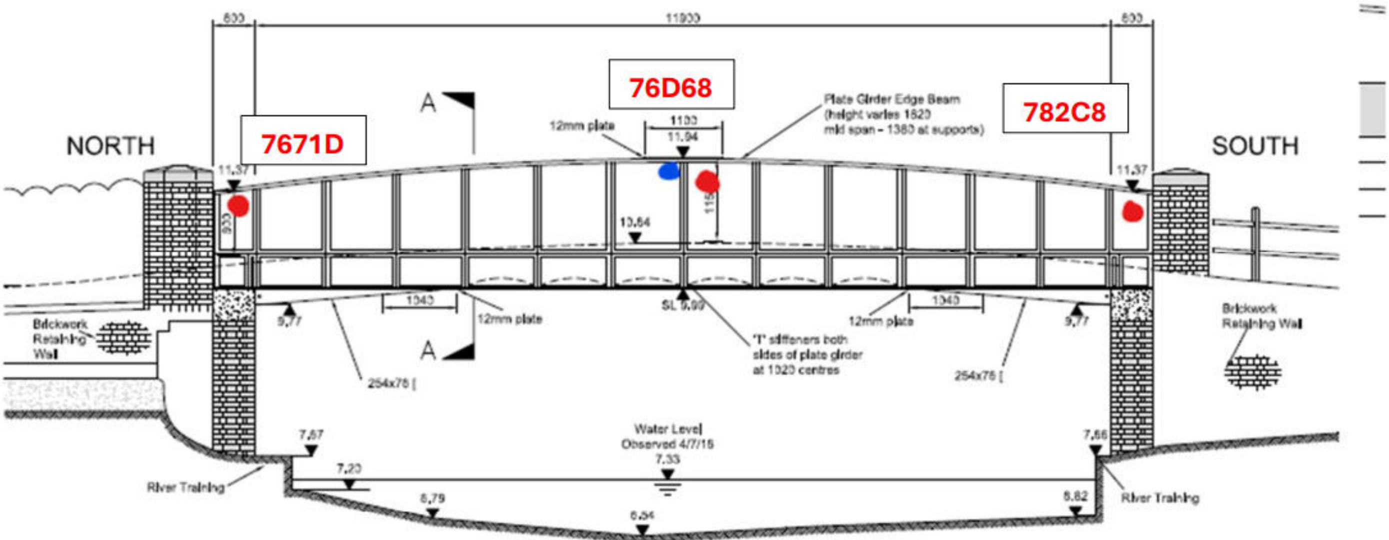
Colchester

Essex

Monitoring brief/objective:

To monitor select positions of the bridge structure (pre-agreed with the client and as shown on the plan overleaf) during load testing being undertaken on behalf of our client. Monitoring required to be in an x,y,z format (Total Station Monitoring) and an inclination degree format (Tilt Sensors).

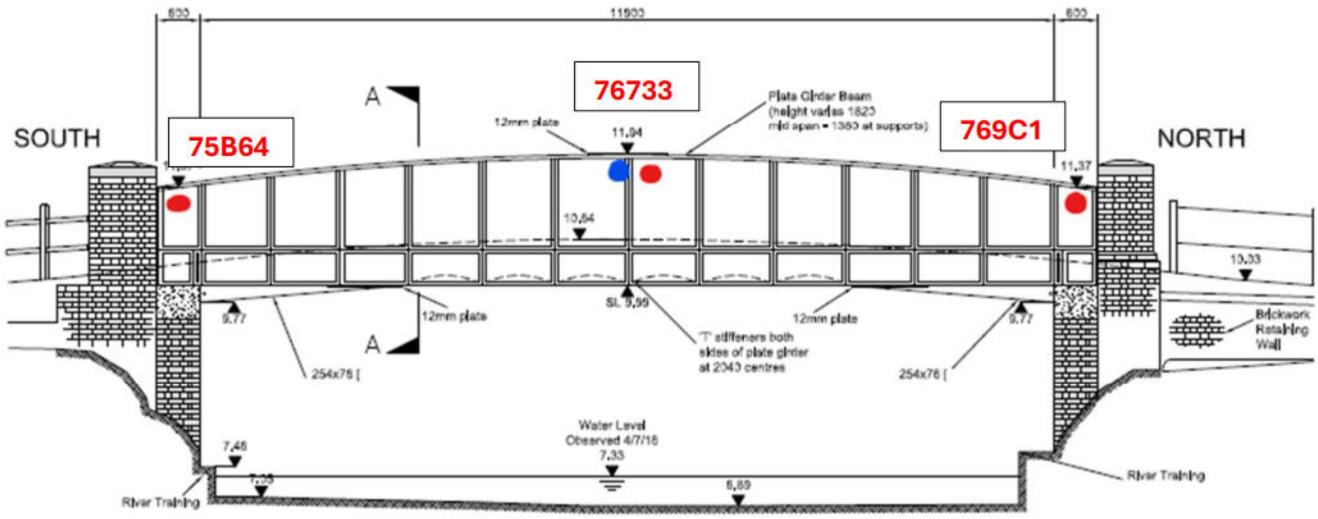
Sensor/prism placement plan



UPSTREAM (WEST) ELEVATION

WATERWAY AREA= 37.70 m²

Scale 1:50



DOWNSTREAM (EAST) ELEVATION

WATERWAY AREA= 36.15 m²

Scale 1:50

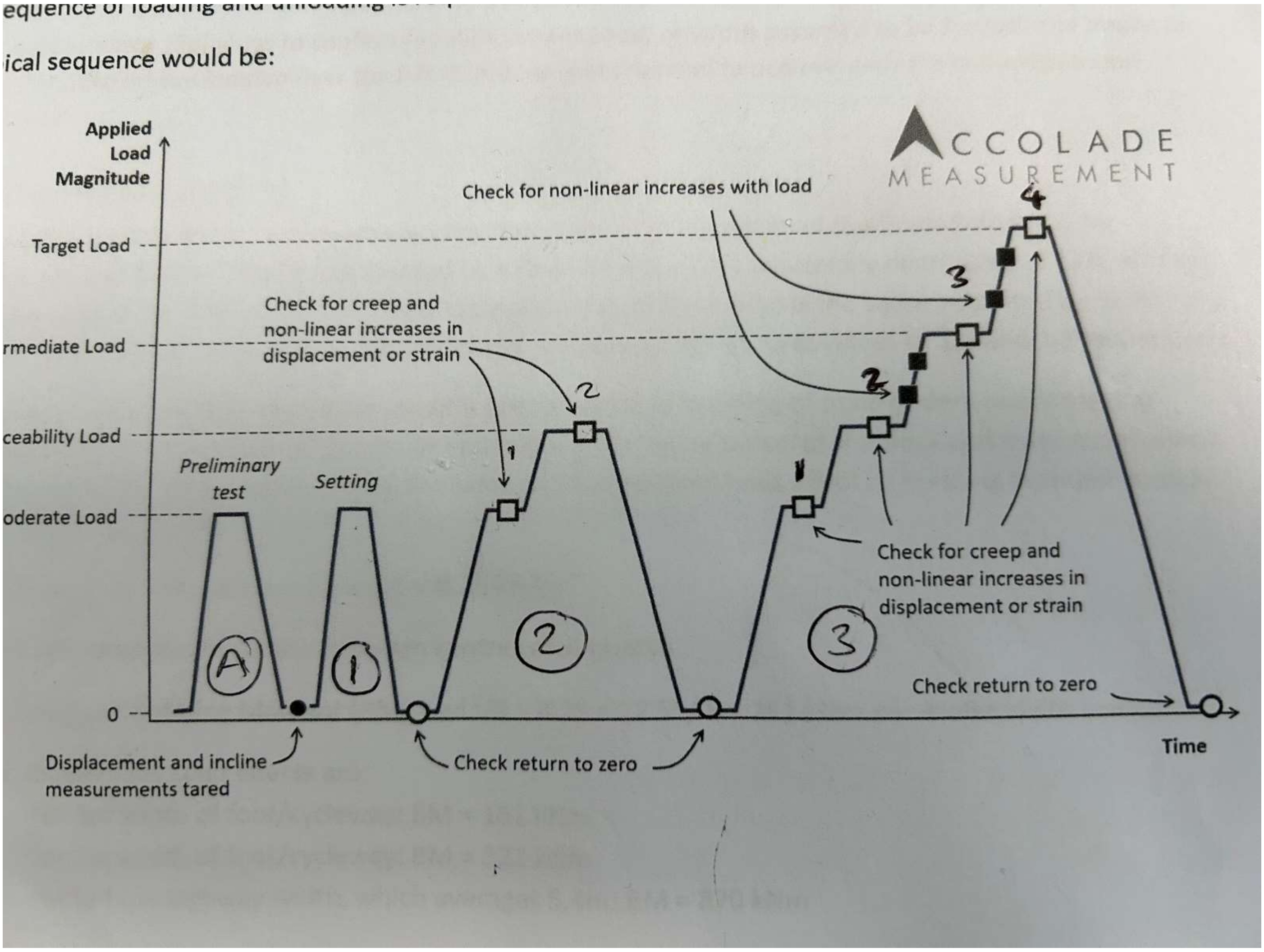
Key:

Red dots – Locations of Tilt Sensors and Tilt Sensor reference numbers (EUI)

Blue dots – Locations of monitoring targets for Total Station monitoring (L- Bar prisms)

Program of works:

2661/M1 - Boxted Bridge - Monitoring log/schedule of events			
Date	Time	Item	Data/comments
Mon 8th Sept 2025	12:00 - 14:30	Monitoring	Base readings and testing
Tues 9th Sept 2025	08:00 - 16:30	Monitoring	Set up and continued monitoring. Third party undertaking various set ups and preliminary tests (tasks and timings unknown)
Wed 10th Sept 2025	08:00 - 10:00	Monitoring	Set up and continued monitoring. Third party undertaking various set ups and preliminary tests
	10:15 - 10:25	Monitoring	Filling for Setting test (Section 1)
	10:25 - 10:40	Monitoring	Filled and waiting/holding period
	10:40 - 10:52	Monitoring	Emptying
	10:52 - 11:12	Monitoring	Empty and waiting/holding period
	11:12 - 11:20	Monitoring	Filling for first level of serviceability load (Section 2:1)
	11:20 - 11:40	Monitoring	Filled and waiting/holding period
	11:40 - 12:10	Monitoring	Third party break/no activities being undertaken.
	12:10 - 12:17	Monitoring	Filling to second level of serviceability load (Section 2:2)
	12:17 - 12:37	Monitoring	Filled and waiting/holding period
	12:37 - 13:05	Monitoring	Emptying
	13:10 - 13:30	Monitoring	Empty and waiting/holding period
	13:30 - 13:35	Monitoring	Filling to first level of target load (Section 3:1)
	13:35 - 13:55	Monitoring	Filled and waiting/holding period
	13:55 - 14:00	Monitoring	Filling to second level of target load (Section 3:2)
	14:00 - 14:20	Monitoring	Filled and waiting/holding period
	14:20 - 14:30	Monitoring	Filling to third level of target load (Section 3:3)
	14:30 - 14:50	Monitoring	Filled and waiting/holding period
	14:50 - 15:00	Monitoring	Filling to fourth level of target load (Section 3:4)
	15:00 - 15:20	Monitoring	Filled and waiting/holding period
	15:25 - 15:35	Monitoring	Filling to a further unknown level beyond Section 3:4)
	15:35 - 15:55	Monitoring	Filled and waiting/holding period
	16:00 - 16:30	Monitoring	Emptying



Total Station Monitoring – Element 1 of 2

Total Station Monitoring services provided:

- The set up and establishment of monitoring targets and equipment prior to works.
- The set up and establishment of a fixed control network outside the zone of influence.
- Establish base line readings (x,y,z coordinates of the target positions - as shown blue in the sensor/prism placement plan) prior to works i.e. structure in 'normal' state/the reference coordinates. (See supporting documentation Appendix A)
- The continual real-time monitoring of these targets during works and comparison of base readings against actuals.
- On-site reporting based upon readings against trigger levels (as shown below)
- Trigger levels (defined by the client):

  No concern zone = 0-4mm

  Green Zone - Alert = 5mm – 9mm

  Amber Zone – Warning = 10mm-14mm

  Red Zone – Critical = 15mm +
- Total Station data can be seen in **Appendix A**

Notes:

Total Station monitoring subject to equipment tolerances (+/- 1-2mm).

Total Station 'live monitoring' - triggers set for movement as shown above and until these are breached data isn't recorded. It is visually checked on site at the source by the resident engineer.

Resident engineer to advise if triggers are exceeded.

Resident engineer to record periodic data in line with the program and as agreed with the client in addition to the 'live monitoring' (as can be seen in Appendix A).

APPENDIX A

2661/M1 - Boxted Bridge - Monitoring log for TS East of bridge/schedule of events					Differences		
Date	Time	Item	Data/comments	Reading	Eastings	Northings	Z value
Wed 10th Sept 2025	08:00	Monitoring	Set up and continued monitoring. Third party undertaking various set ups and preliminary tests	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	10:00	Monitoring	Set up and continued monitoring. Third party undertaking various set ups and preliminary tests	E-1005.570, N-1014.170, Ht-12.953	0.001	0	0.001
	10:15	Monitoring	Filling for Setting test (Section 1)	E-1005.570, N-1014.170, Ht-12.952	0.001	0	0
	10:25	Monitoring	Filled and waiting/holding period	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	10:40	Monitoring	Emptying	E-1005.569, N-1014.171, Ht-12.952	0	0.001	
	10:52	Monitoring	Empty and waiting/holding period	E-1005.569, N-1014.170, Ht-12.953	0	0	0.001
	11:12	Monitoring	Filling for first level of serviceability load (Section 2:1)	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	11:20	Monitoring	Filled and waiting/holding period	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	11:40	Monitoring	Third party break/no activities being undertaken.	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	12:10	Monitoring	Filling to second level of serviceability load (Section 2:2)	E-1005.569, N-1014.171, Ht-12.952	0	0.001	0
	12:17	Monitoring	Filled and waiting/holding period	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	12:37	Monitoring	Emptying	E-1005.571, N-1014.170, Ht-12.952	0.002	0	0
	13:10	Monitoring	Empty and waiting/holding period	E-1005.569, N-1014.170, Ht-12.954	0	0	0.002
	13:30	Monitoring	Filling to first level of target load (Section 3:1)	E-1005.569, N-1014.170, Ht-12.952	0	0	
	13:35	Monitoring	Filled and waiting/holding period	E-1005.569, N-1014.170, Ht-12.953	0	0	0.001
	13:55	Monitoring	Filling to second level of target load (Section 3:2)	E-1005.569, N-1014.169, Ht-12.952	0	-0.001	0
	14:00	Monitoring	Filled and waiting/holding period	E-1005.570, N-1014.169, Ht-12.952	0.001	-0.001	0
	14:20	Monitoring	Filling to third level of target load (Section 3:3)	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	14:30	Monitoring	Filled and waiting/holding period	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	14:50	Monitoring	Filling to fourth level of target load (Section 3:4)	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	15:00	Monitoring	Filled and waiting/holding period	E-1005.570, N-1014.170, Ht-12.952	0.001	0	0
	15:25	Monitoring	Filling to a further unknown level beyond Section 3:4)	E-1005.569, N-1014.171, Ht-12.952	0	0.001	0
	15:35	Monitoring	Filled and waiting/holding period	E-1005.568, N-1014.170, Ht-12.952	0	0	0
	15:55	Monitoring	holding period	E-1005.568, N-1014.170, Ht-12.953	0	0	0.001
	16:00	Monitoring	Emptying	E-1005.569, N-1014.170, Ht-12.953	0	0	0.001
	16:30	Monitoring	Empty	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	17:05	Monitoring	Final Reading	E-1005.569, N-1014.170, Ht-12.952	0	0	0
	Station set up towards the East of the bridge. North is located looking directly at the bridge. + north movements means bridge wall moving inwards.						

2661/M1 - Boxted Bridge - Monitoring log for TS West of bridge/schedule of events					Difference		
Date	Time	Item	Data/comments	Reading	Easting	Northings	z value
Wed 10th Sept 2025	08:00	Monitoring	Set up and continued monitoring. Third party undertaking various set ups and preliminary tests	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	10:00	Monitoring	Set up and continued monitoring. Third party undertaking various set ups and preliminary tests	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	10:15	Monitoring	Filling for Setting test (Section 1)	E-1008.493, N-1001.582, Ht-13.774		-0.001	0
	10:25	Monitoring	Filled and waiting/holding period	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	10:40	Monitoring	Emptying	E-1008.494, N-1001.583, Ht-13.773	0.001	0	-0.001
	10:52	Monitoring	Empty and waiting/holding period	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	11:12	Monitoring	Filling for first level of serviceability load (Section 2:1)	E-1008.493, N-1001.583, Ht-13.773	0	0	-0.001
	11:20	Monitoring	Filled and waiting/holding period	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	11:40	Monitoring	Third party break/no activities being undertaken.	E-1008.492, N-1001.584, Ht-13.774	-0.001	0.001	0
	12:10	Monitoring	Filling to second level of serviceability load (Section 2:2)	E-1008.493, N-1001.583, Ht-13.774		0	0
	12:17	Monitoring	Filled and waiting/holding period	E-1008.492, N-1001.583, Ht-13.774	-0.001	0	0
	12:37	Monitoring	Emptying	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	13:10	Monitoring	Empty and waiting/holding period	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	13:30	Monitoring	Filling to first level of target load (Section 3:1)	E-1008.493, N-1001.584, Ht-13.775	0	0.001	0.002
	13:35	Monitoring	Filled and waiting/holding period	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	13:55	Monitoring	Filling to second level of target load (Section 3:2)	E-1008.491, N-1001.583, Ht-13.774	-0.002	0	0
	14:00	Monitoring	Filled and waiting/holding period	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	14:20	Monitoring	Filling to third level of target load (Section 3:3)	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	14:30	Monitoring	Filled and waiting/holding period	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	14:50	Monitoring	Filling to fourth level of target load (Section 3:4)	E-1008.494, N-1001.583, Ht-13.774	0.001	0	0
	15:00	Monitoring	Filled and waiting/holding period	E-1008.495, N-1001.583, Ht-13.774	0.002	0	0
	15:25	Monitoring	Filling to a further unknown level beyond Section 3:4)	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	15:35	Monitoring	Filled and waiting/holding period	E-1008.493, N-1001.583, Ht-13.772	0	0	-0.002
	15:55	Monitoring	holding period	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	16:00	Monitoring	Emptying	E-1008.493, N-1001.584, Ht-13.774	0	0.002	0
	16:30	Monitoring	Empty	E-1008.493, N-1001.583, Ht-13.774	0	0	0
	17:05	Monitoring	Final Reading	E-1008.493, N-1001.582, Ht-13.774	0	-0.001	0
			Station set up to the North west of the bridge. North for this station is set towards the south meaning reading towards the west is bridge wall moving inwards.				

Wireless Sensor Monitoring – Element 2 of 2

Wireless Sensor Monitoring services provided:

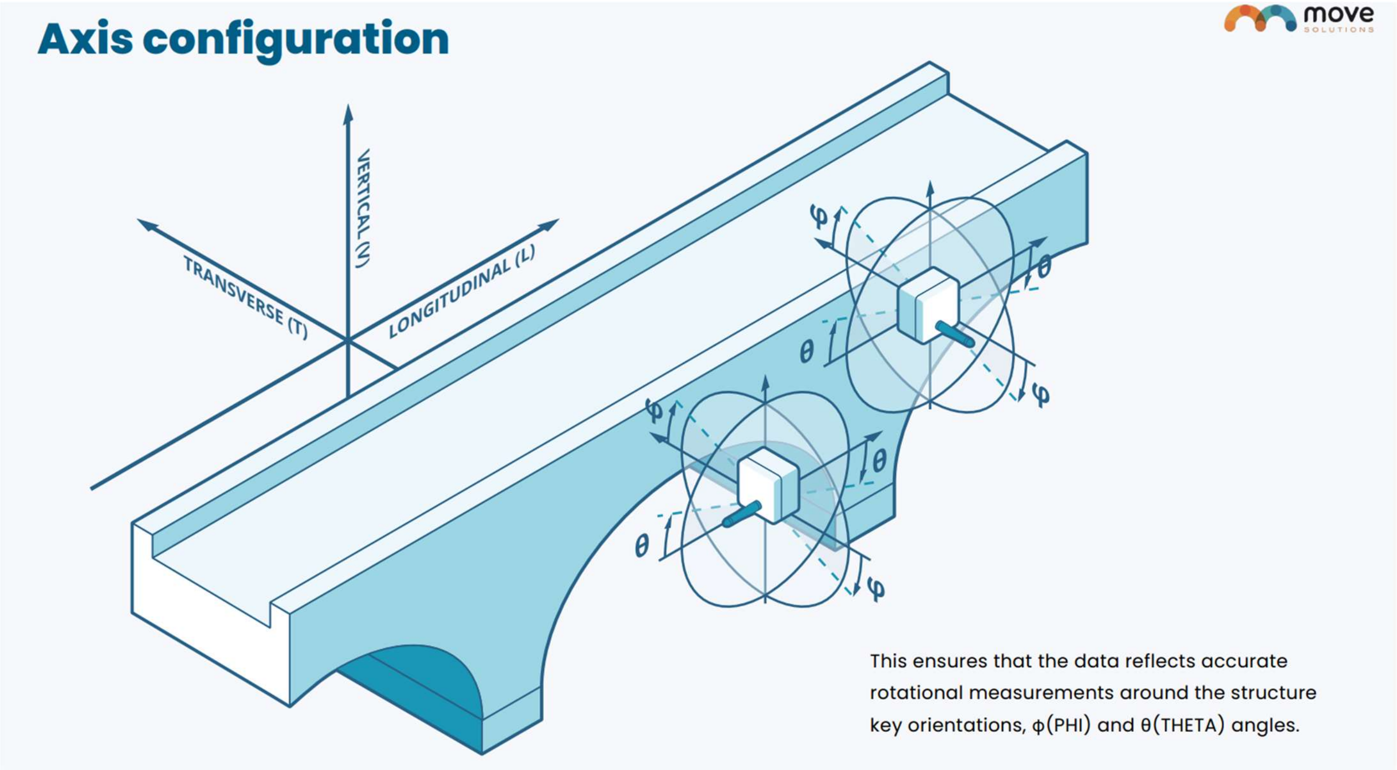
- The set up and establishment of:
    - Tilt sensors x 6 (in locations as shown red in the plan above)
    - Monitoring Gateway.
    - System off-grid power source.
    - IoT platform for monitoring and reporting.
- Zero all sensors to give a baseline (zero degrees inclination in all axis) and collect further readings after this prior to works i.e. structure in 'normal' state. Please note this was only possible for a few hours so the natural state of the structure couldn't be monitored.
- Inclination trigger levels (defined by the client)

    No concern zone – Inclination of 0-0.49 degrees in any axis.

    Green Zone - Alert – Inclination of 0.51-0.79 degrees in any axis

    Amber Zone – Warning – Inclination of 0.8 – 0.99 degrees in any axis

    Red Zone – Critical – Inclination of 1 degree or greater in any axis
- Notification of trigger levels being exceeded as per the above reported directly to the client
- Tilt meter sensor data collected at 2-minute intervals (as decided by the client) during works.
- The continual monitoring of tilt meter sensor data during works (loading) was undertaken.
- Tilt meter monitoring data can be seen in **Appendix B**.



APPENDIX B

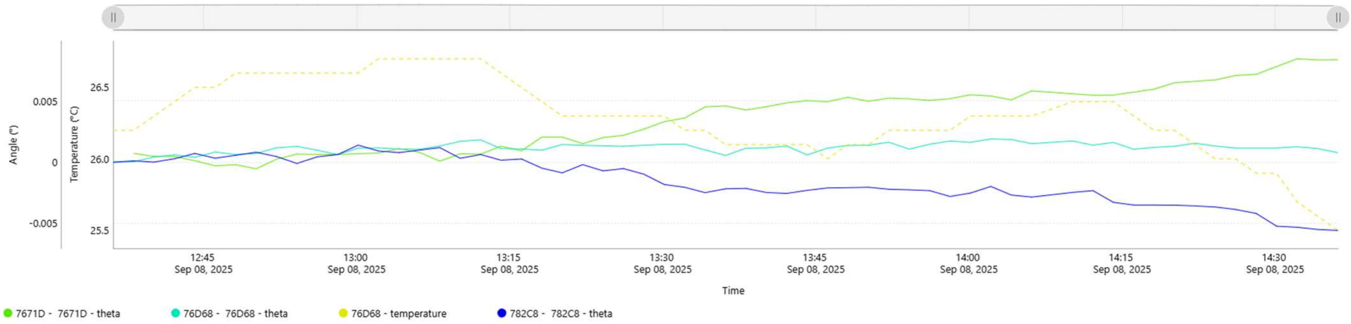
8th Sept Data:

Boxted Bridge
Load Testing

Add Profile

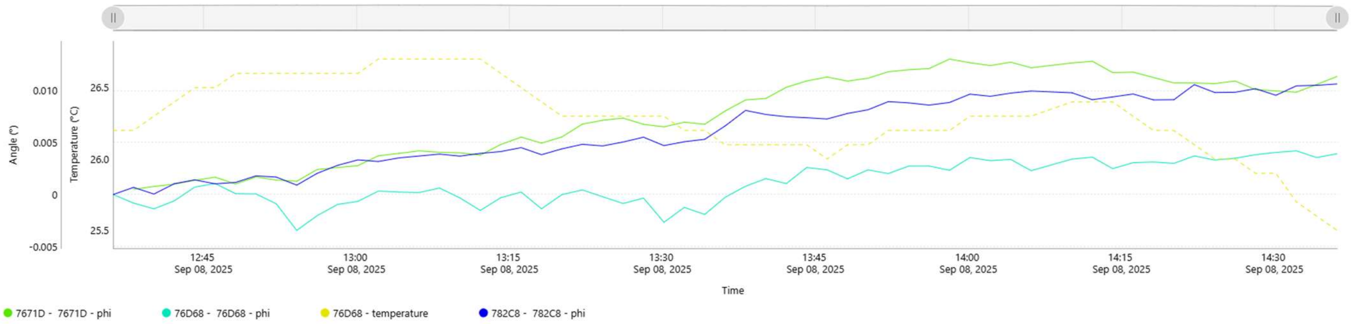
Boxted West Theta

Date range: 08/09/2025 - 08/09/2025



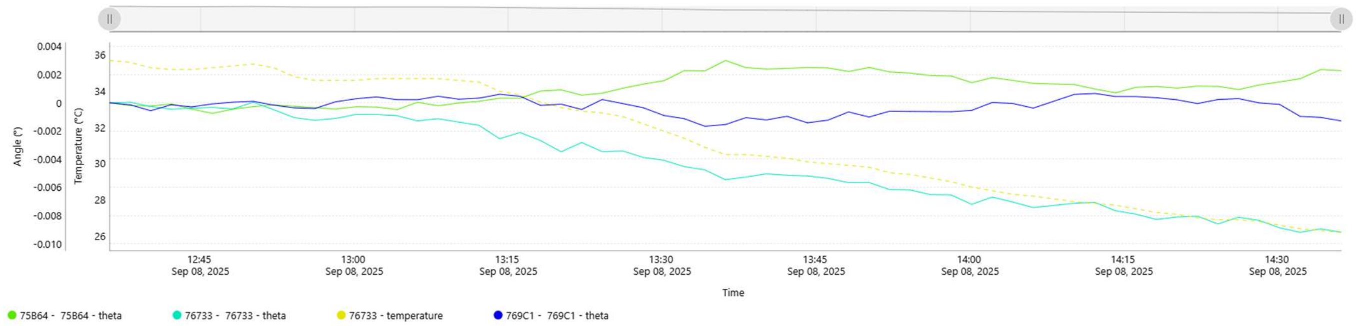
Boxted West Phi

Date range: 08/09/2025 - 08/09/2025



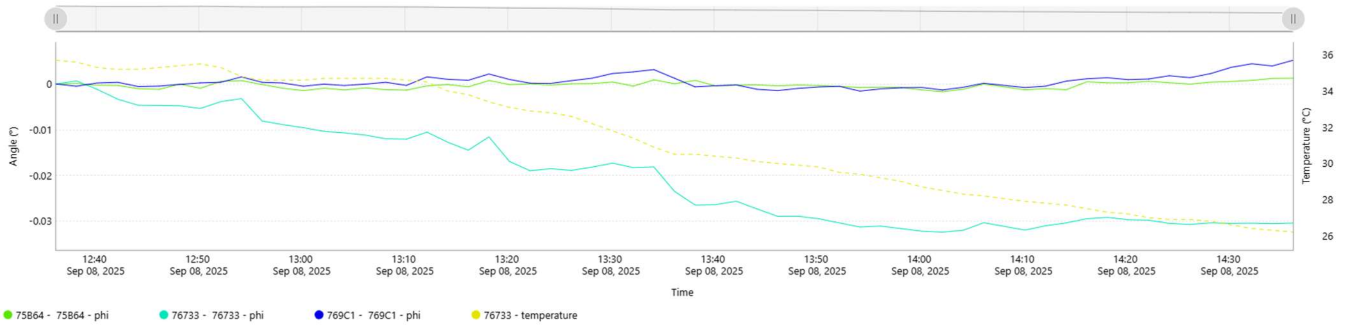
Boxted East Theta

Date range: 08/09/2025 - 08/09/2025

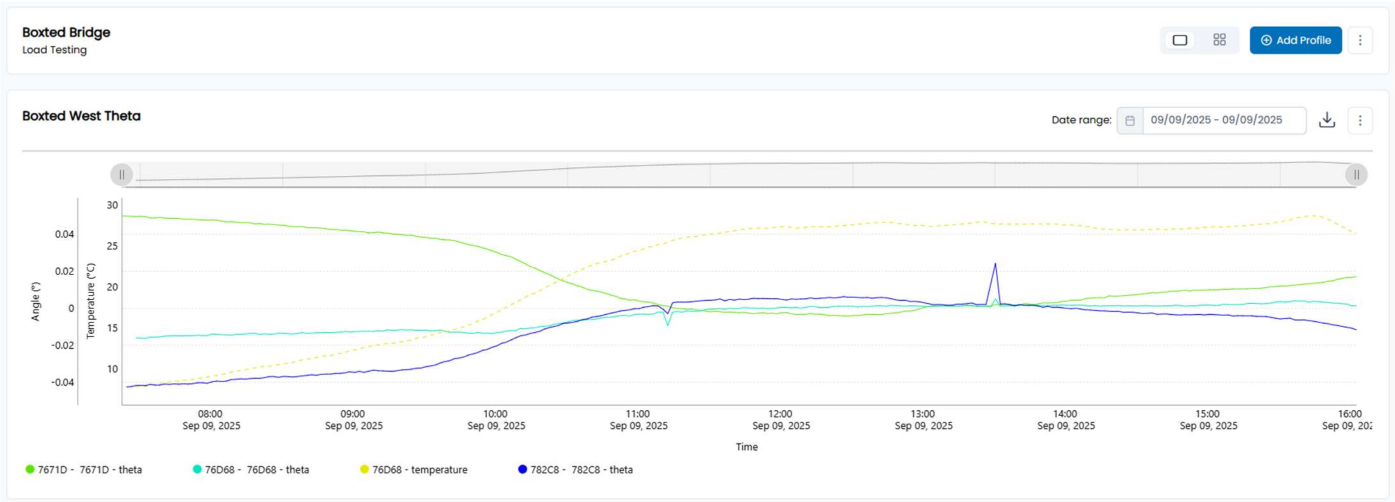


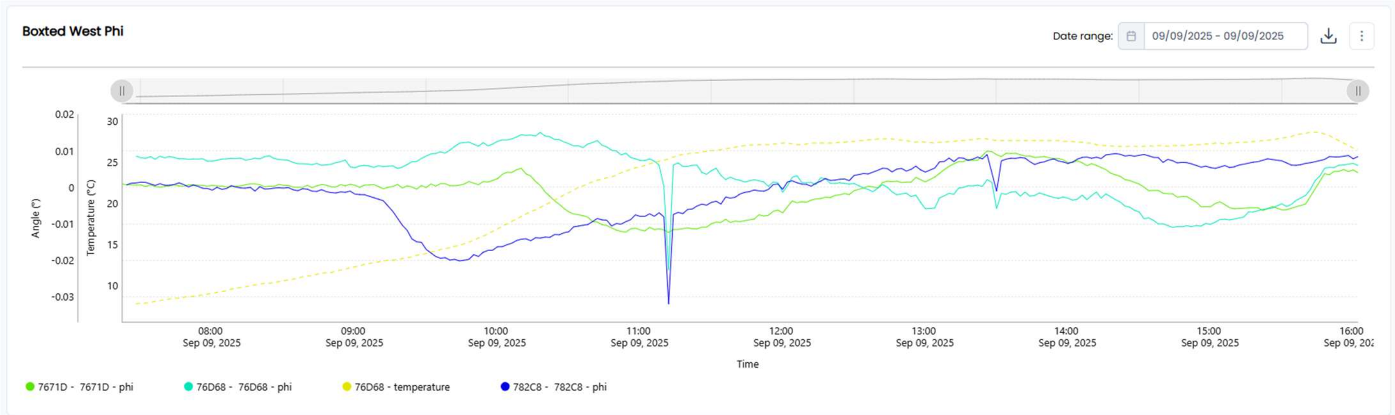
Boxted East Phi

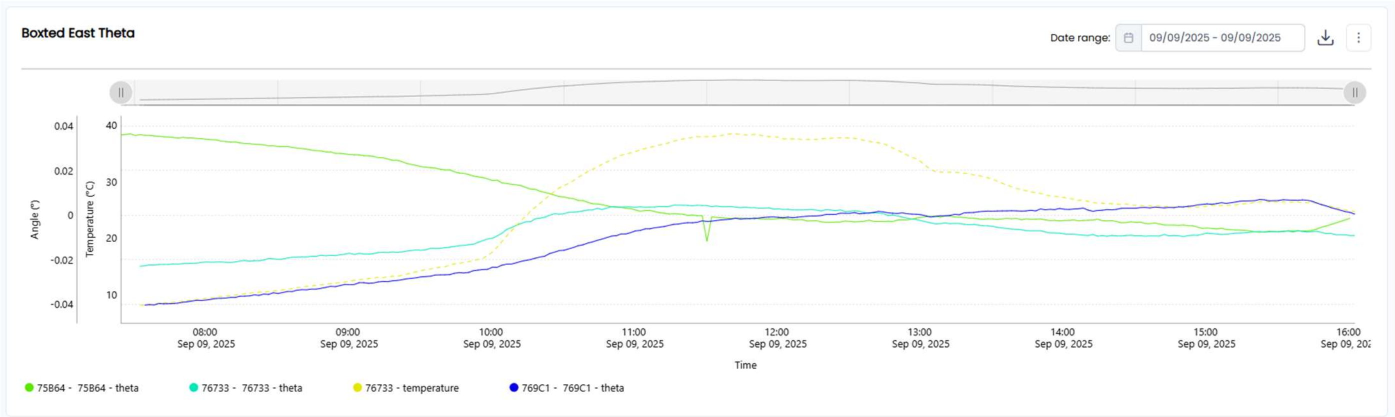
Date range: 08/09/2025 - 08/09/2025

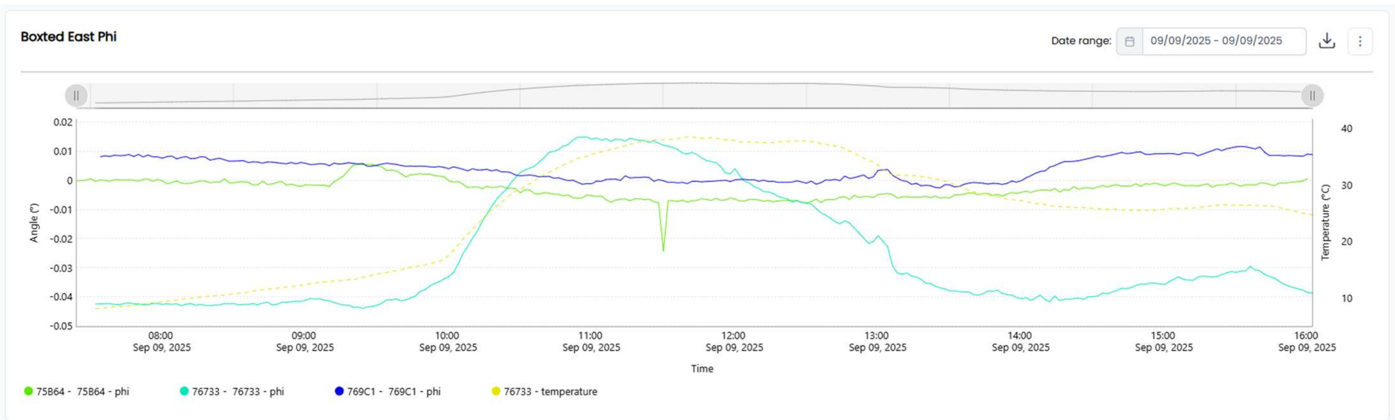


9th Sept Data:









<u>10th Sept Data:</u>