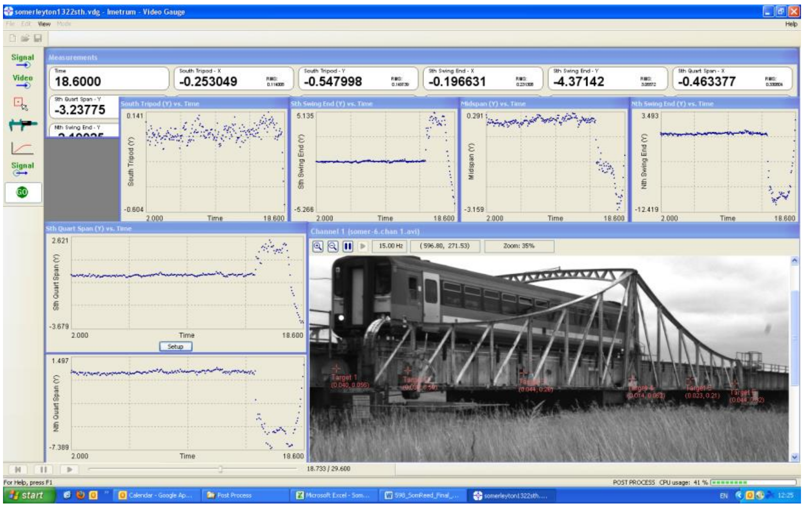
Swing Bridge, UK

Date: May 2013
Contract Value: <£5k
Ultimate Client: Network Rail



Imetrum was instructed to measure dynamic displacement of the deck, using a single camera Imetrum Video Gauge, measuring at 15 Hz. Monitoring of a number of discreet points was specified to a resolution of 0.5 mm or better. 4" bullseye targets (shown below right) were used to define the precise location for monitoring to help tie the results back to the structural model of the bridge.

Imetrum took videos using a 5 megapixel video camera with a 16 mm low distortion lens. Videos were recorded for approximately 10 seconds before and after each train entered and left the swing section of the bridges. These were used to generate vertical displacement measurements at six locations for each bridge using Imetrum's patented software. Monitoring locations are as follows:

- Nearest pier to the camera.
- Both ends of the swinging central section.
- Bridge midspan (pivot point).
- Both quarter spans.

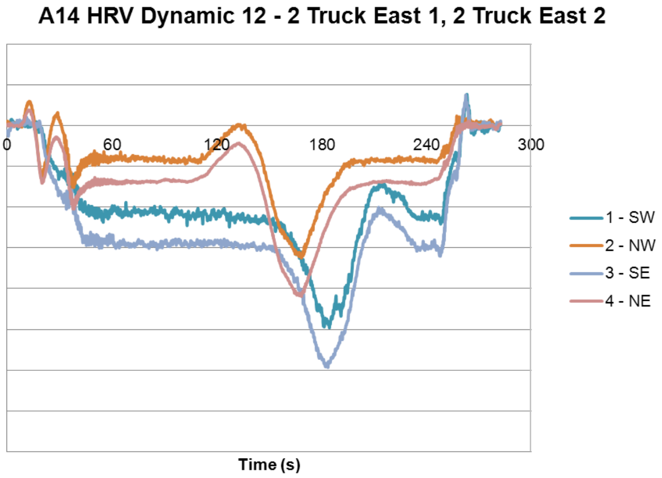
The Imetrum Video Gauge was positioned approximately 15 m from the bridge, mounted on a wooden surveyors tripod, and levelled. It was positioned to be able to get a good view of the swing section of the bridge. Data from Imetrum's camera was fed into a System Controller, which was used to record videos during the passage of each train. Recordings were taken until videos of four trains had been captured travelling in each direction on each bridge. The trains were a mixture of Class 153 (one carriage) and Class 156 (two carriage). At each location, at least one train of each class in each direction was captured.

Whilst the system can be used to take measurements live in the field, a thorough processing of the data can also be performed after the event, using video recorded live. This was the technique used in this instance. Displacement values are generated by converting the movement in pixels seen by the camera to movements in mm via a scaling for each point monitored. This scaling was done both using a model of the camera and lens, and using objects of known size within the image. In all cases, these two scaling methods agreed to within 4%.

- Vertical deflections were monitored using a single camera Imetrum Video Gauge.
- Simultaneous non-contact Dynamic measurements were recorded at six points on each structure.
- Site setup location and measurement requirements were different from planned, but measurement resolutions of better than 0.5mm were still achieved.

4 Lane Highway Bridge, UK

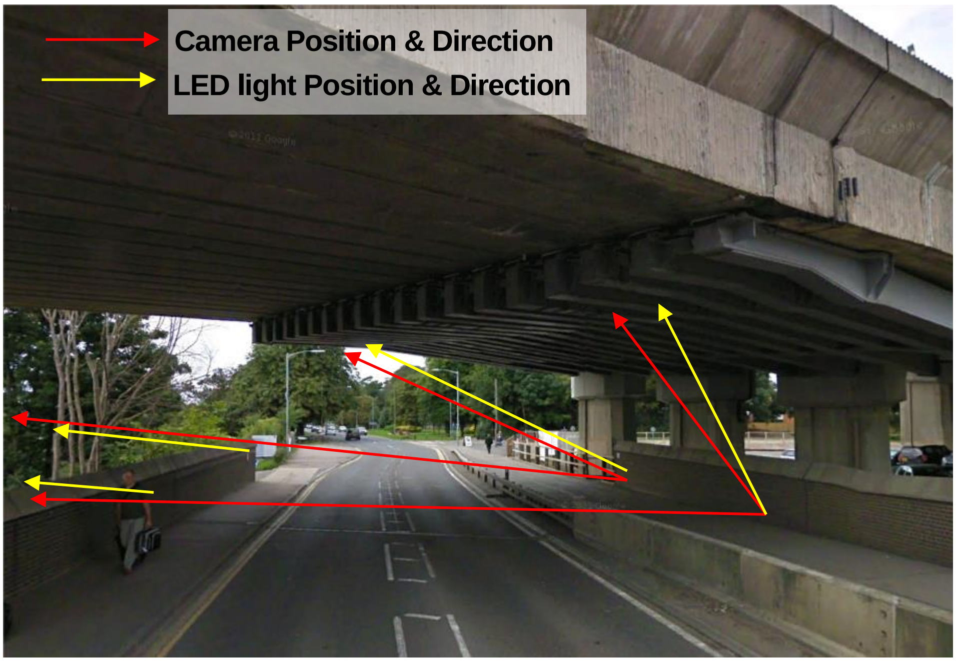
Date: October 2012
Contract Value: £5k - £20k
Ultimate Client: Highways Agency



Imetrum was asked by the Highways Agencies' Managing Contractor, to attend the structure on the night of 20th / 21st October 2012 to undertake vertical displacement monitoring during load testing of this critical structure. Monitoring of four points (indicated below) was specified to a resolution of 0.1 mm or better.

Imetrum took vertical displacement measurements at four locations (two on the North half-joint, two on the South half-joint). Measurement resolutions were typically 0.02 mm for the Northern half-joint & 0.05 mm for the Southern half-joint (see below for further details). These measurements will be compared with laser based measurements in order to compare and validate the displacement measurements of the structure. These measurements provided valuable data for the immediate bridge assessment, as well as helping to inform long term monitoring and maintenance strategies, including refining the Finite Element model of the structure.

For the purposes of this test, a single camera was used per measurement location, in order to generate the most accurate measurements possible. As a relatively static loading regime was used, then displacement values were recorded at a frequency of 5 Hz. Bullseye targets were applied to the structure to enable the most accurate Imetrum measurements. The targets were between 8 m and 44 m from the cameras. The four cameras were synchronised so that images were captured at exactly the same time, and fed into a system controller . This was used for generating real time measurements for the structrural engineer to see during the test, and recording videos for more detailed analysis off-line. 12 volt LED lighting was used to illuminate the target areas, with a single 15 W light used per location. A total of 27 different load patterns were planned for the evening testing. Data traces for each load case were provided to the client, along with full data.



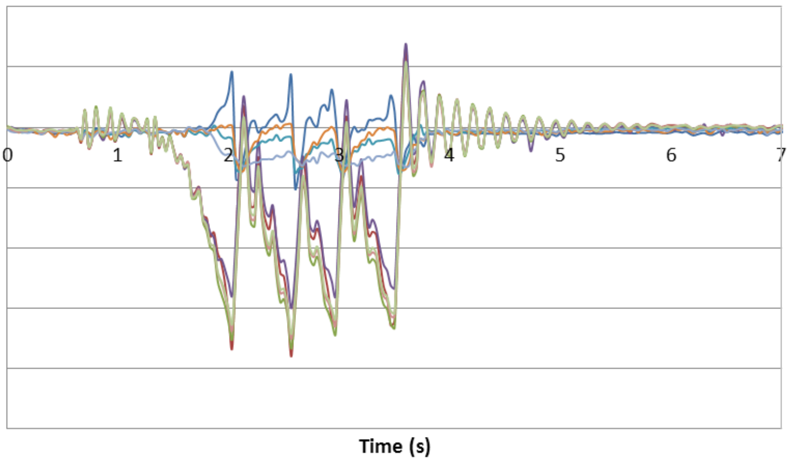
Canal Bridge, UK

Date: November 2012
Contract Value: <£5
Ultimate Client: Network Rail

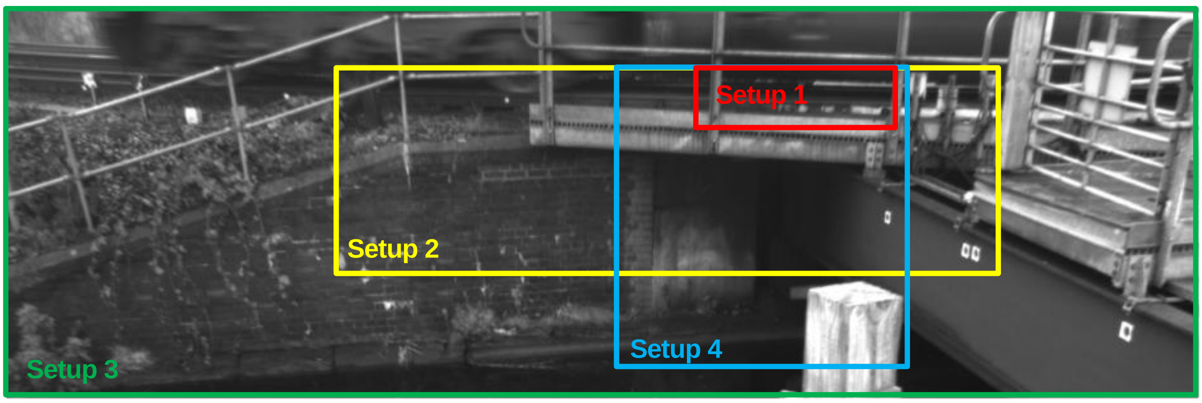
Imetrum were asked to attend this structure for a day to undertake vertical displacement monitoring during the passage of trains operating under a normal timetable.

Monitoring was undertaken using a single camera portable Imetrum Video Gauge system, using a camera mounted on a standard surveyor's tripod.

Vertical displacement measurements were taken at a number of locations on up and down lines, bridge beams, abutments and foundations (where visible). The tripod-mounted Video Gauge was placed at three separate locations, with ten different setups used in total to provide a mix of wide-area summary data and more detailed investigations. All of this was achievable within a single working day on site. The wider angle views produce data with a resolution around 0.1 mm. Narrower views have more detail in the image from which to calculate measurements, and therefore achieve higher resolutions (around 0.01 mm).



Line speed is 50 mph at this section, although in practice many of the trains travelled slower than this. In order to get a good combination of speed and displacement resolution, a 30 Hz recording speed was used for the purposes of the test. Predominantly, the natural patterning of the structures were used by the system as measurement points, although some self-adhesive vinyl targets were attached to the steel bridge beams where there was very limited pattern, and in six locations, paint marks were added to the rails to provide greater definition. Weather was overcast and misty throughout the period of data gathering.



Data generated identified where exactly on the structure and foundations excessive movement was coming from, enabling areas for remedial work to be defined swiftly. Additionally, as video data had been recorded, the nature of the movement during load events could be observed for additional characterisation of the structure and confidence in the results.

Imetrum Resolution Investigation: Highway Bridge, UK

Date: October 2012
Contract Value: £5 - £20k
Ultimate Client: Highways Agency

Resolution for the video gauge is normally determined by calculating the standard deviation of the generated measurement during steady-state conditions. It is dependent on five principle factors:

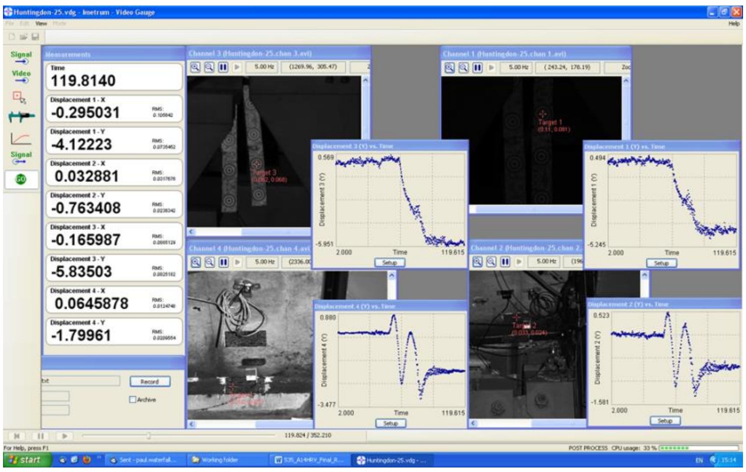
- Size of the area being measured (field of view);
- Quality of the target (pattern and lighting);
- Stability of the camera mounting;
- Hardware specification (cameras and lenses);
- Distance to the target (and hence the impact of atmospheric effects).

Whilst it is a legitimate technique to average over a number of readings to take account of random effects (and this is used by many monitoring systems), we wanted to test the ‘raw’ measurement resolution to verify experimental setup. The three calibration runs provided an excellent opportunity to do this. Below are tabulated values (in mm), of standard deviation of measurements during these tests.

Load Case	1-South West (44 m)	2-North West (14 m)	3-South East (38 m)	4-North East (8 m)
Calibration 1	0.05 mm	0.02 mm	0.04 mm	0.01 mm
Calibration 2	0.06 mm	0.03 mm	0.04 mm	0.01 mm
Calibration 3	0.06 mm	0.03 mm	0.06 mm	0.01 mm

Vertical deflections were monitored simultaneously at all four points requested in the specification, using a single Imetrum Video Gauge system with four cameras and four LED lights.

- Measurements were taken at 5Hz to correspond with the static nature of the load testing
- Resolutions of better than 0.1 mm were achieved for all monitoring locations, with resolutions of 0.01 mm achieved for the best setup (4-North East).



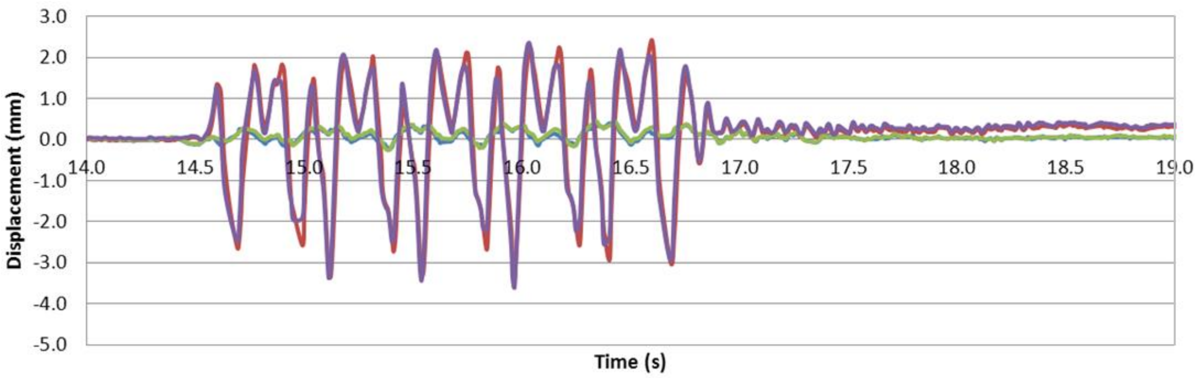
Track Deflection, High Speed Line

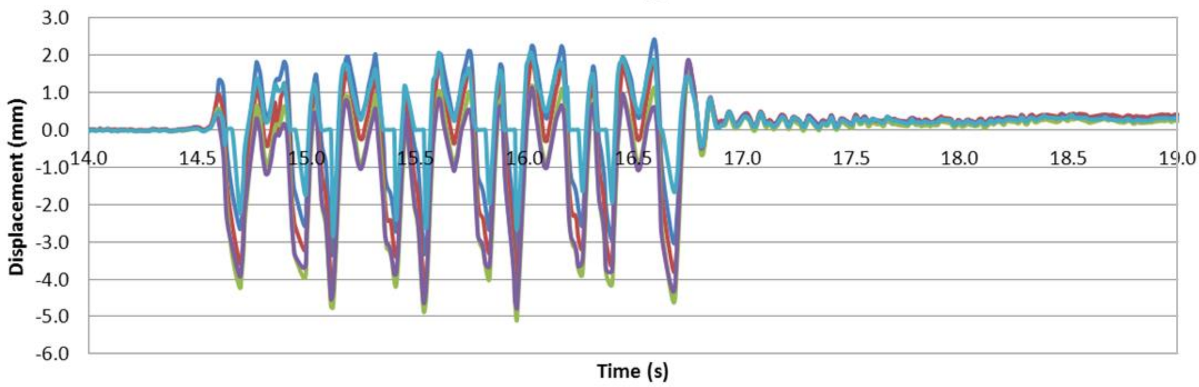
Date: June 2013
Contract Value: <£5k
Ultimate Client: Network Rail

Imetrum was requested to monitor deflection under train loading at normal line speed (120 mph).

The ability to generate displacement values to a suitably high resolution without the need to access the track to install any physical targets was the reason for choosing Imetrum's Video Gauge. The system allowed precise data to be generated (see graphs below), and the considerable expense of accessing the track to install targets was spared. The work was undertaken at a location which was identified as requiring a speed restriction to due to larger than expected vertical train movements, and the Video Gauge was able to simultaneously characterise displacement of sleepers, clips and ballast, using no more than their appearance within a single video feed as a target for the software to follow.

The work confirmed the need for a speed restriction to be in place, and also justified (and accelerated the implementation of) the remedial works.





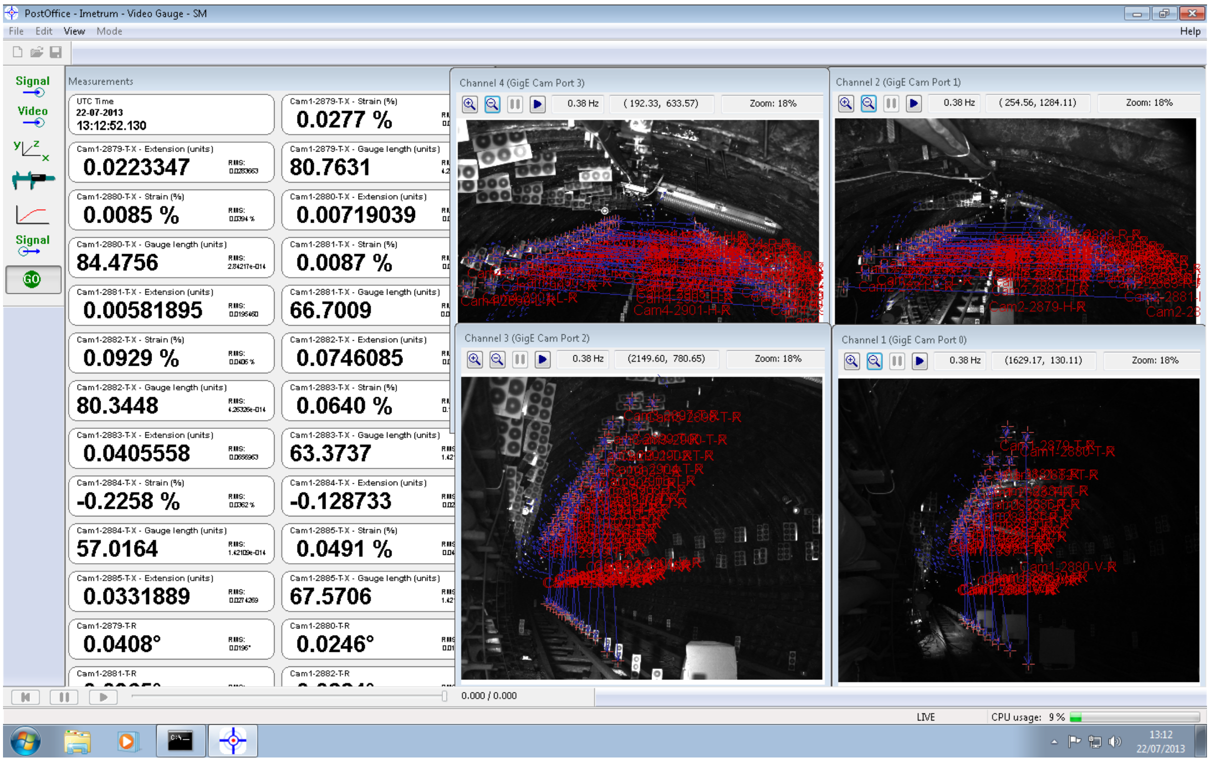
Detailed Tunnel Ring Investigation: UK

Date: Jan 2013 – August 2014
Contract Value: –
Ultimate Client: Crossrail

As part of a research project by the CSIC (Cambridge Centre for Smart Infrastructure in Construction), Imetrum was asked to undertake detailed monitoring of horizontal and vertical tunnel convergence & rotation. Imetrum were also asked to monitor the variation in movement between individual bolted ring segments every 0.5 m of a 30 m section of this cast iron tunnel. (A total of 500 measurements)

The project is for an approximately 18 month period. This allows for several months of baseline data, followed by monitoring of movement during an initial tunnel bore, then subsequent widening works to create a station in the new tunnel.

A four camera Imetrum system was used, to cover the required length of tunnel to the specified resolution: 0.1 mm. Targets were fitted to the front and back face of each tunnel ring, in order to provide sufficient pattern (and defined locations) for the software to track movement. Infra-red lighting was used, and targets kept to a maximum width of 60 mm to ensure that the system did not disturb the path of any trains. The study is currently ongoing, with early indications that measurement resolution is as specified.



Masonry Bridge, UK

Date: July 2013
Contract Value: -
Ultimate Client: University of the West of England

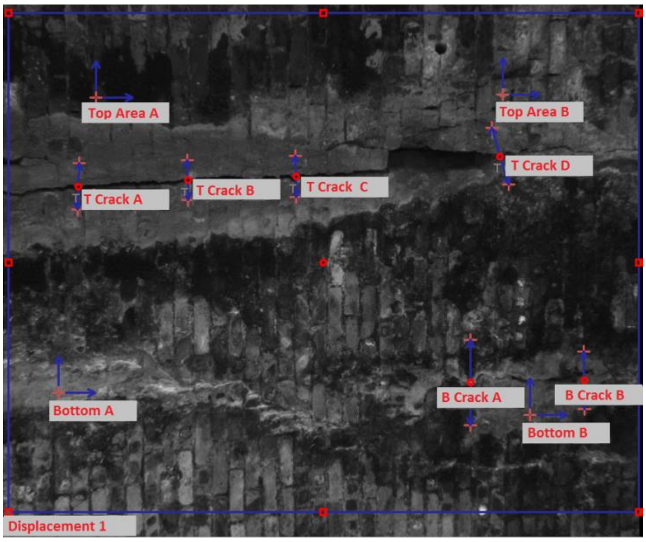
Imetrum was asked to measure dynamic displacements of this brick arch bridge carrying a mainline connection to Bristol Temple Meads. The system was set up under the arch of interest (approximately 6 m high) using a single camera, tripod mounted to look vertically at the apex of the bridge arch from below.

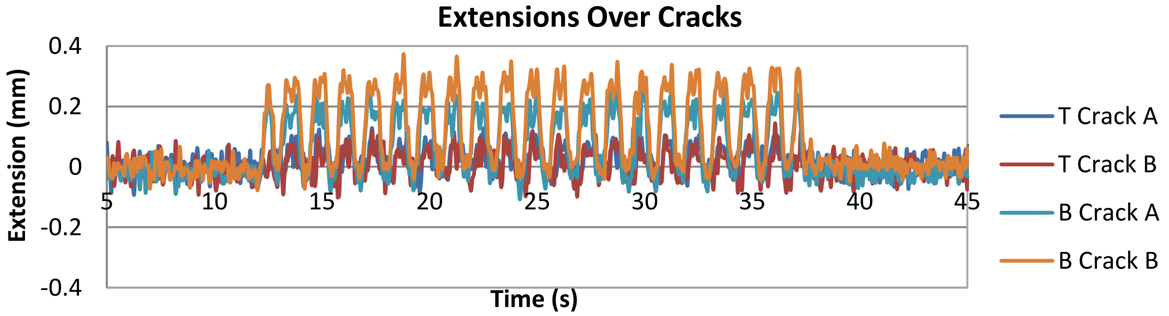
The structure has two obvious cracks running parallel to track direction. Video was recorded during the passage of a freight train over the bridge, with a view to monitoring the movement of the structure around these cracks. The system was operated with both 'full-field' and point-point measurements, in order to characterise the overall structural movement and give some more precise values to the magnitudes of movement recorded.

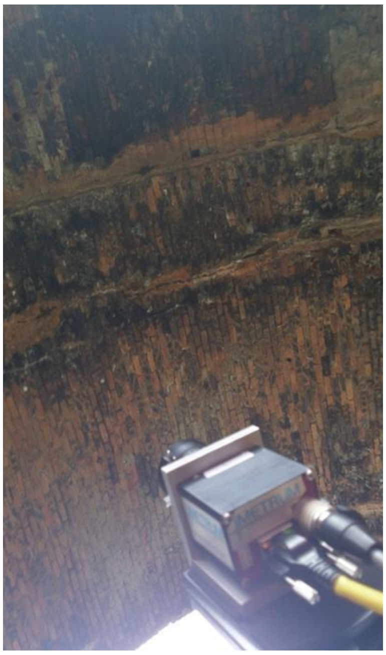
Below you can see a still capture of the video feed, displacement maps, screenshots and tabulated maximum and minimum data, all obtained following a one hour site visit. Also shown are three sample graphs of the extensions and displacements from 'virtual extensometers positioned across the visible cracks and 'virtual displacement transducers' arranged around the captured image.

The data obtained returned resolutions of better than 0.05 mm in the worst case, and better than 0.02 mm in the best case. Maximum deflections observed were around 0.5 mm. A link to sample videos from the freight train loading event is available by emailing info@imetrum.com. These videos clearly indicate the areas of movement over the arch and expose the differences in movement each side of the cracks.

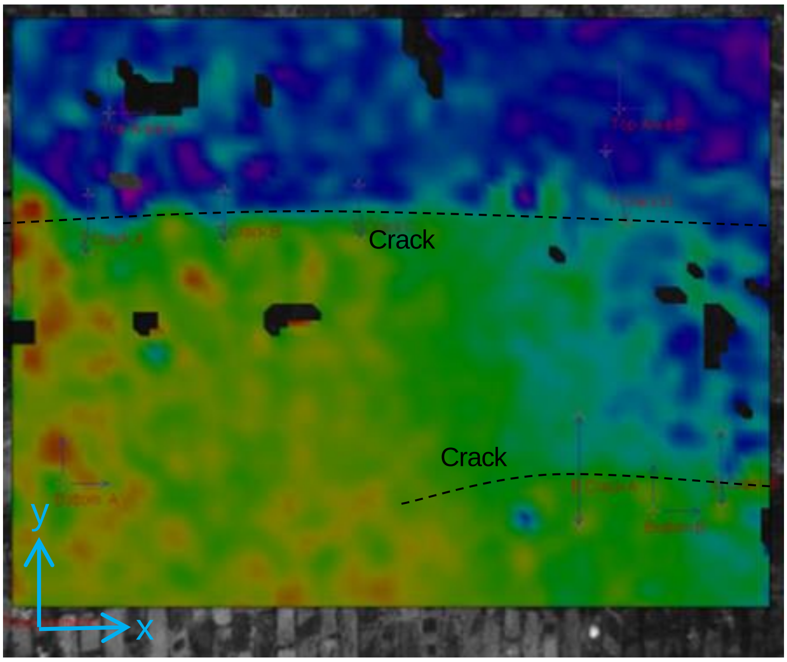
Type	Location	Max [mm]	Min [mm]
Extension	T Crack A	0.134	-0.092
Extension	T Crack B	0.144	-0.101
Extension	T Crack C	0.138	-0.081
Extension	T Crack D	0.104	-0.076
Extension	B Crack A	0.268	-0.107
Extension	B Crack B	0.373	-0.077
Deflection	Top Area A	0.221	-0.149
Deflection	Top Area B	0.143	-0.075
Deflection	Bottom A	0.252	-0.094
Deflection	Bottom B	0.442	-0.164



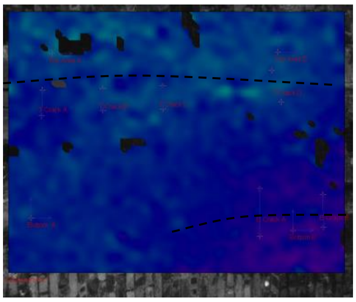




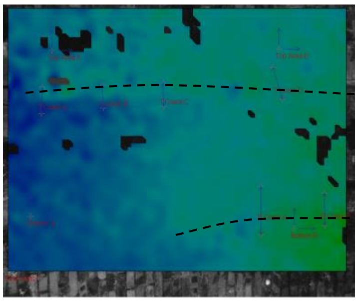
View of Brick Arch from Ground



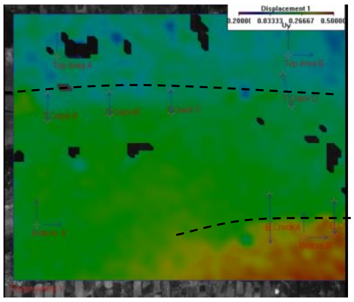
Displacement Map [x] – Train on Bridge



Displacement [y] – Unloaded

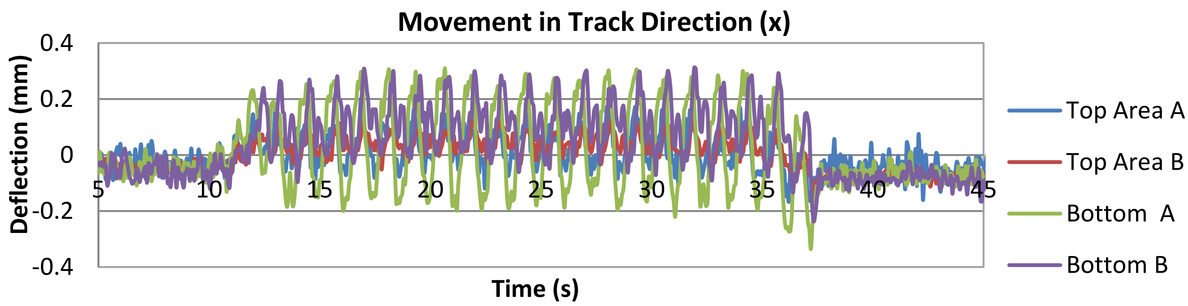


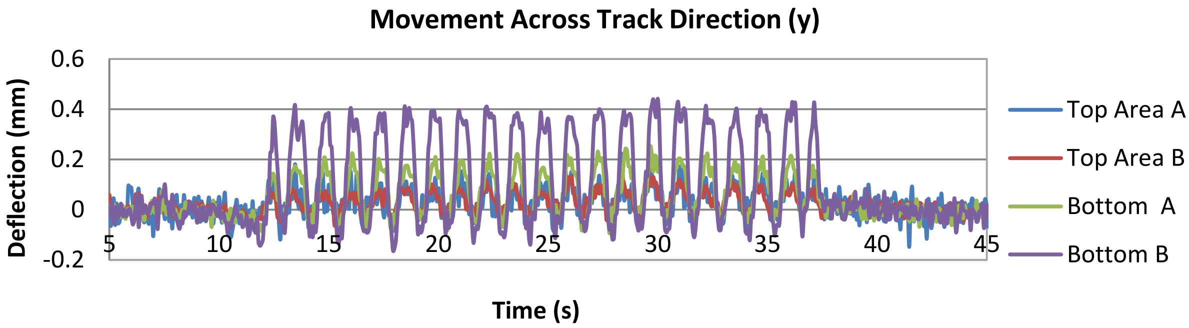
Displacement [y] – Part Load



Displacement[y] – Full Load

Dynamic Deflections





Open Front Drilling (Pipe Drilling), NL

Report: RailAssist Imetrum Benelux
Date: 2 October 2013
Contract Value: -
Ultimate Client: Prorail, Dutch Railway Company

Imetrum Benelux was asked to continuously measure the displacement of two tracks whilst a 1.2 m diameter concrete pipe was driven through the railway embankment at Griendsveen using open front drilling. The Imetrum Video Gauge was set up on the embankment at a point of safety, and outside of the anticipated zone of influence of the pipe drilling. Setup was 3.5 m from the nearest rail and fenced by a tactile chain to comply with the safety rules of Prorail. A single tripod-mounted camera system was focused on a section of track directly on top of the line of the concrete pipe, at a shallow elevation. Real time measurement data was captured, recorded and displayed using Video Gauge software from a point of safety at the foot of the embankment. This allowed the contractor to monitor any impact of their works on track alignment instantaneously. During the pipe drilling there was normal train traffic running on the line.

Monitoring during Pipe Jacking

From 2014, Prorail will specify continuous monitoring of pipe drillings for all pipes over 1.2 m diameter in order to guarantee the safe running of trains. For this reason, Imetrum's Video Gauge was compared with a total station, which has traditionally been the instrument of choice for this type of track monitoring. Prior to implementing this new monitoring requirement, Prorail was looking to ensure the best value method of obtaining high quality track displacement data.

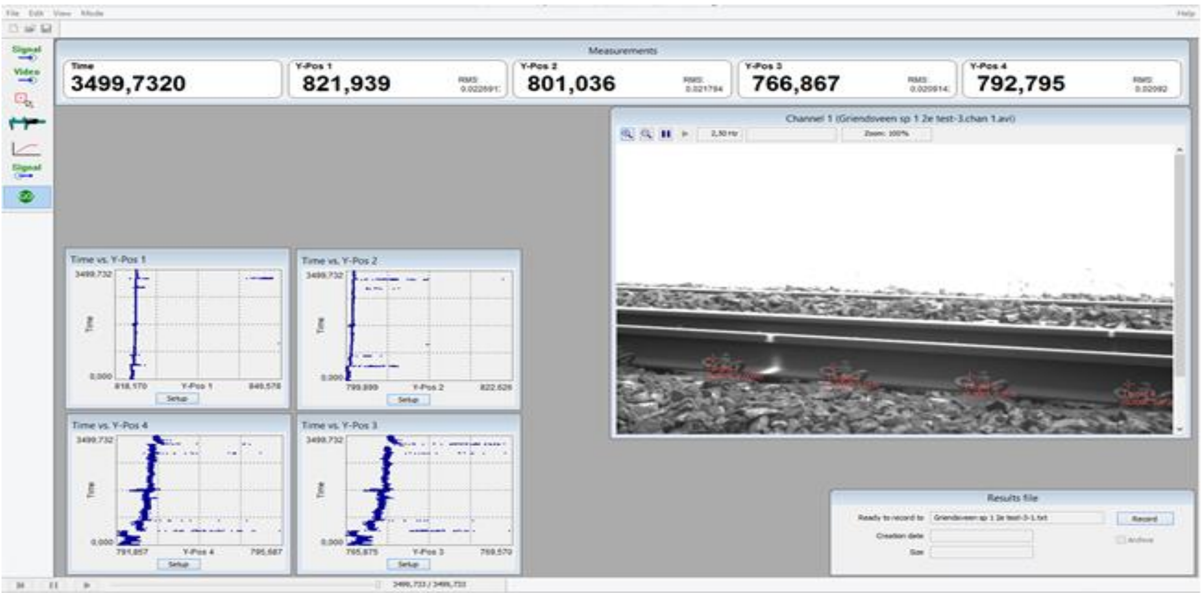
As the Video Gauge is able to use natural patterns on a structure to monitor movement, there was no need to obtain a track possession to add reflective targets on the rails, saving money by eliminating the approval process, and also saving time in arranging the track possession. The project is also safer, as there was no need for surveying staff to access the track. Additionally, as the Video Gauge is able to monitor multiple points simultaneously at over 100 Hz, all points of interest can be monitored under train loading, giving a more accurate picture of the impact of the works on ride quality and likelihood of derailment.

Monitoring from Point of Safety

The sample frequency of the camera was set to 2.5 Hz in this instance. The field of view was defined as 9 m on each side of the line of drilling. The Video Gauge can run on 12 V batteries for a normal site day, but in this instance was powered by an on-site generator. The system used the natural pattern of the rail clips as virtual targets for monitoring displacement at each sleeper. A screen shot of the video gauge software during operation, including 4 graphs of vertical displacement, is shown below.

For this project it was agreed that as long as the track deflection was within ± 2 mm, the drilling could continue. If the track deflection was exceeded, the speed of the drilling would be lowered or stopped. The actual safety value for this particular track is a vertical displacement of the sleeper of 20 mm. The horizontal lines in the graphs represent the passing of trains which leads to a normal elastic deformation of the track construction. The data obtained had returned calculated resolutions of about 0.03 mm, much higher accuracy than the ±1 mm required by Prorail. At the end of the drilling the data showed that the movement of the tracks was within a band width of +1 and -2 mm, well within the safety limits.

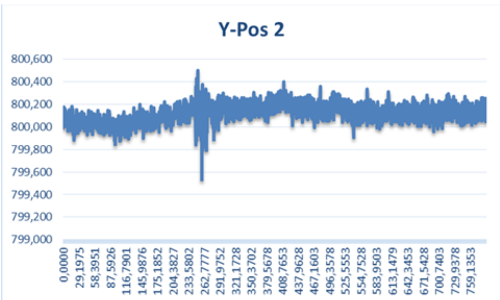
	Video Gauge	**Total Station**
Absolute displacement	Yes	Yes
Track possession needed	No	Yes
Dynamic measurement	Yes	No
Measurement under loading	Yes	No
Accuracy	≤ 0.1 mm	1 mm

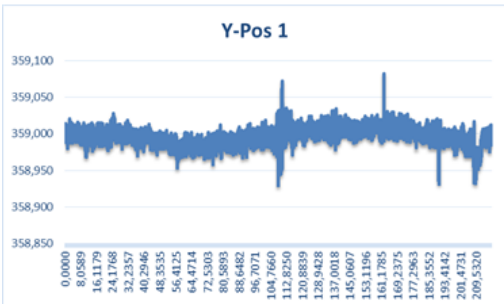


More information about this project is available by contacting RailAssist Imetrum Benelux at info@railassist.com.


Video Gauge Camera on Survey Tripod

Open Front Drilling Apparatus






Real Time Data Monitoring on Laptop


Installing Pipe Drilling Equipment