PROJECT DOSSIER

BOGIBEEL RAIL CUM ROAD BRIDGE PROJECT

Project	BOGIBEEL RAIL CUM ROAD PROJECT
Location	Dhemaji & Dibrugarh District, Assam, India
Client	NEFR
Consultant	RITES
Contractor	Hindustan Construction Company
Designer	Ramboll
Duration	Sept 2018-Nov 2018

PROJECT OVERVIEW

Bogibeel is a 4.94 km combined Rail cum Road Bridge, second longest in Asia, built over Brahmaputra River in the north eastern region of India. It is built across Dhemaji and Dibrugarh districts of Assam, India.

The construction of the bridge consists of composite welded steel-concrete beams/trusses that can withstand earthquake of magnitudes up to 7 on the Richter scale. The bridge has a two lane rail track on the lower deck and three lane road on the upper deck. The bridge is designed in such a way that it has the capacity to transfer army troops/tanks and even fighter jet landings.

WHY MONITORING?

The bridge has a total of 39 spans of 125 m each and 2 end spans of 32.4 m each. Out of this, one normal span and one end span on the North bank required load test to check the over range capacity of the bridge. The load test was conducted at the stage of commissioning of bridge. Instrumentation was required for real time monitoring of the load test being conducted. Strain gauges, thermocouples, displacement sensors were installed to test the strain developed at full load, variation of temperatures and displacement of the bearings of bridge span. Encardio-rite were entrusted with the complete monitoring works.

MONITORING SOLUTION

Load testing was required at a normal span of 125 m and an end span of 32.4 m on the North bank. The instruments installed were automated to collect data (before and after the load application) to monitor the variations and impact loads along with characteristics and responses of the bridge like temperature, displacement and geometry profiles of the bridge deck, static stress/strain distribution throughout the structure and overall performance for the load test.

Turnkey services

- Supply of sensors, dataloggers, geodetic targets and weather station
- Installation & commissioning
- Automatic monitoring with dataloggers
- Real-time web-based data management system

INSTRUMENT USED

Existing bridge monitoring	
Strain gage	Used on the midpoints/endpoints of trusses as lower main chords, diagonals and top cross girders for strain measurement.
Thermocouples	Used on midpoints of trusses as lower & upper main chords for measuring steel surface temperature and also concrete temperatures at the underside of concrete deck.
Displacement Sensors	Used to monitor displacement at the center line of bearing (fixed and free) and structural member of the truss and also across the expansion joints between the two spans.
Prism targets	Used on the selected lower main chords to monitor X-Y-Z movements.
Automatic Weather Station	Used to monitor the wind speed, wind direction, temperature and humidity
Data Acquisition system	For automatic collection and transfer of monitored data to cloud server with web based data management software

INSTALLATION CHALLENGE

A good amount of ground work had to be done to achieve such results. Installation of 170 strain gauges, 124 thermocouples, 6 displacement sensors, 8 prism targets on the top cross girder mains and intermediate, diagonal girder, bottom chord girder of the normal span and end span, in a short span of time was a challenge. Automatic weather station was installed at the center of normal span to monitor the complete weather parameters to correlate the sensor output. All the installed sensors, including weather installed were connected to Automatic Data Acquisition system for real time data at stakeholder's desk.

Our installation team had a huge task on their hand to complete the above installation and commissioning work within 10 days. Moreover, the installation locations were quite difficult. Our engineers used trolleys and suspended buckets to reach out to the locations to install the sensors.

Another installation challenge was to install arc weldable strain gages without welding, as welding was not allowed on the truss members. Special epoxy was then used to install the strain gages on the surface of the truss members. The special epoxy selected had two special characteristics:

- transfer the strain (of the truss member to strain gage) without any interference or absorption for accurate result
- quick setting, such that the mounting blocks were fixed on the steel surface within 5 minutes. This helped in fixing the strain gage on the mounting blocks in single attempt, as it was difficult to reach high locations again.

Special arrangement were designed to install displacement sensor at fixed and free bearing, above the pier of the bridge.

We completed the humungous task of installing and commissioning the 300 sensors within ten days successfully.

Installation of strain gage at diagonal girder

Installation of thermocouple at top cross girder

ACHIEVEMENT & RESULTS

The Span load test was conducted successfully and the monitoring results obtained confirmed the assumptions made before starting the bridge load test. The monitoring results matched the expected values defined by the designers Ramboll. No abnormality was found between the highway deck and the railway bridge.

A combined static load test including both highway and railway loadings was performed. The static load test was performed in three different categories:

- Deck (Highway loading)
- Tracks (Railway loading)
- Combined Deck and Track loading

In all the three categories, the initial step was to take the readings at no load.

Deck load testing

For deck load testing, the loading was increased gradually by placing concrete blocks and structural pieces loaded on the structural frames at designated locations. The variation in the strain distribution through the structure, displacement and geometry profiles of the bridge and the ambient temperature, concrete temperature and steel temperature in the body was noted during the loading and unloading and the full load and no load was monitored for 24 hours. Longitudinal displacement of bearings and expansion joints were also noted.

Deck loading

Track load testing

For track load testing, the loading was provided in the form of the train engine and wagons. The load procedure followed was similar to the deck load testing and similarly the variations in all the instruments installed on the steel structure, bearings and expansion joints were monitored.

Track loading

Combined track and deck load testing

For combined track and deck load testing, the railway track and highway deck were loaded simultaneously with the concrete blocks, steel structures and the engine with wagons.

Load test was carried for two segments:

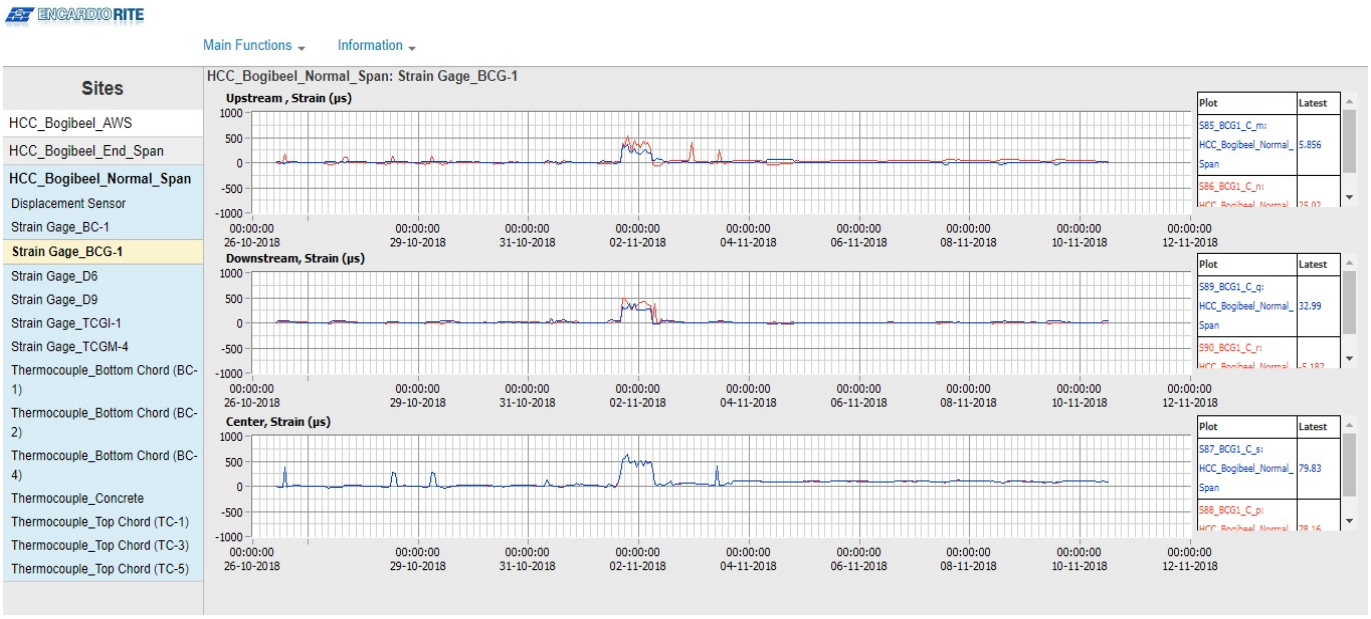
- TLT1 – Track Load Test with engine and wagons parked on both the railway track, a maximum load of 2016 tons.
- TLT2 -Track Load Test with engine and wagons parked on one railway track, a maximum load of 969.30 tons.

Incremental loads were applied and the change in strain, displacement and temperature was displayed in real time with our web based data management software DRISHTI.

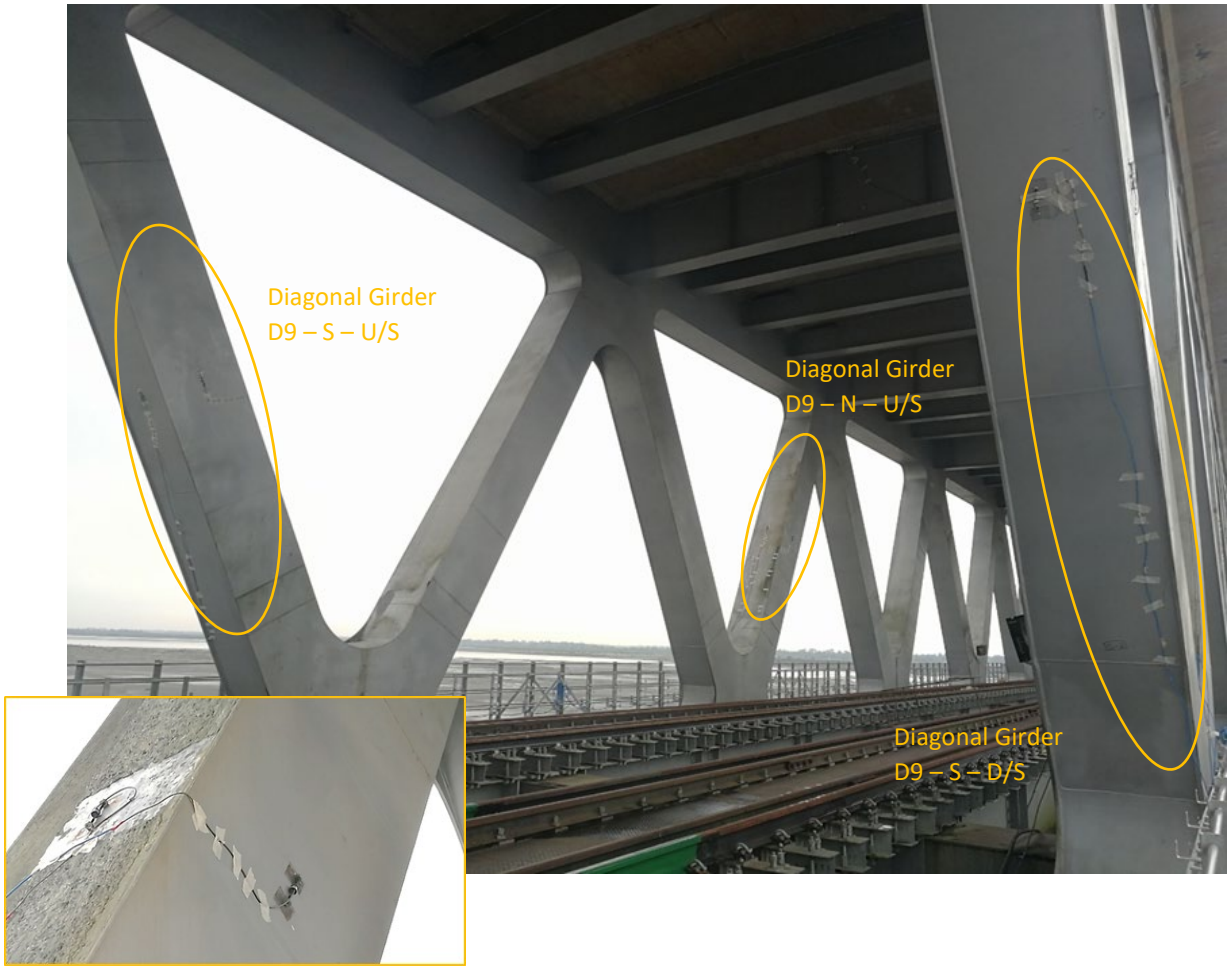
Overall the effect of the day temperature (high), sunrise, sunset and night temperature (low) along with wind on strain measurement (steel surfaces of girders), displacement measurement (of expansion joints, fixed and free bearings) and temperature measurement (of steel surface and underside of the concrete deck) showed results as per the expected variations.

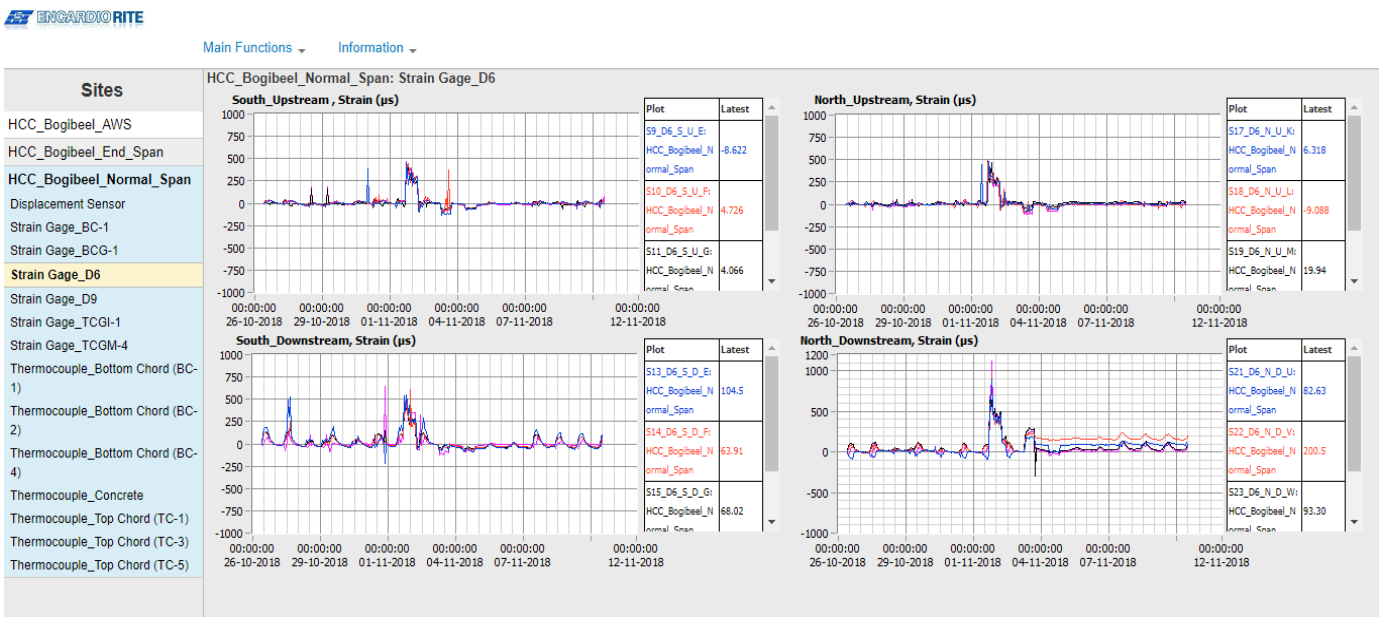
For e.g. the strain and displacement varied along with the combined effect of load applied and the ambient temperature. Increased load applied on the structure increased the strain, displacement on various components of truss like diagonal girder, top cross girder mains and intermediate, bottom chord girder. Few typical results are shared below.

Strain gages and thermocouple installed on bridge

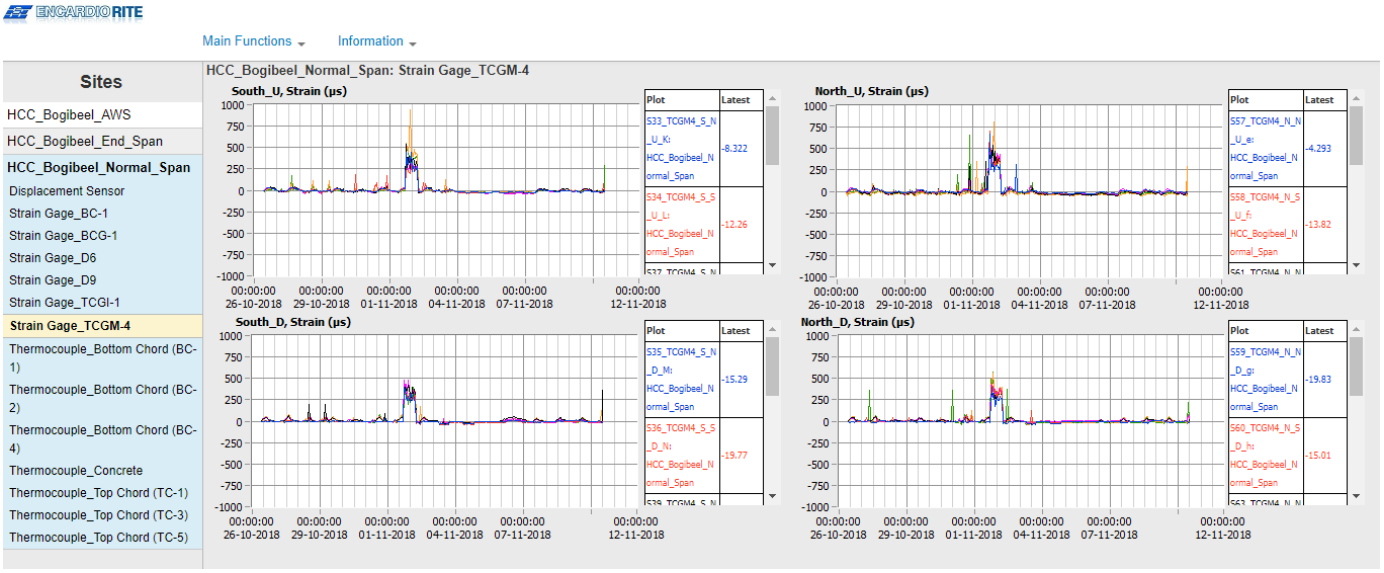


Strain gauge installed on Bottom Chord Girder of Normal Span showing variations in strain during the Load test

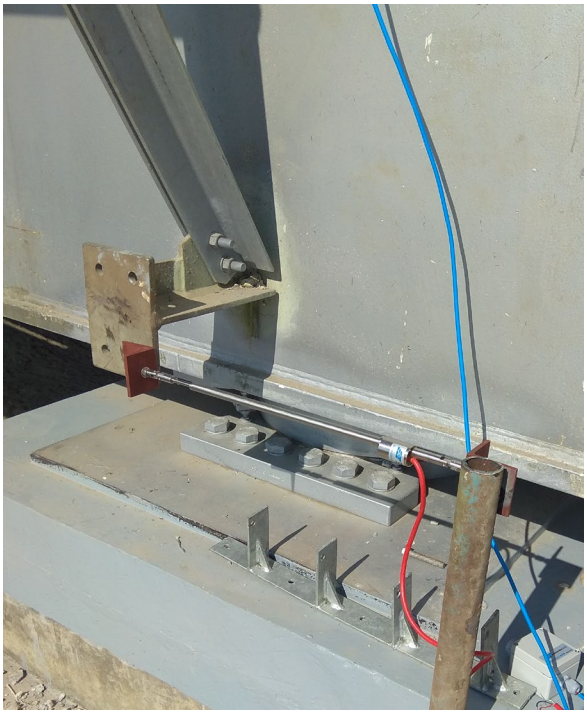




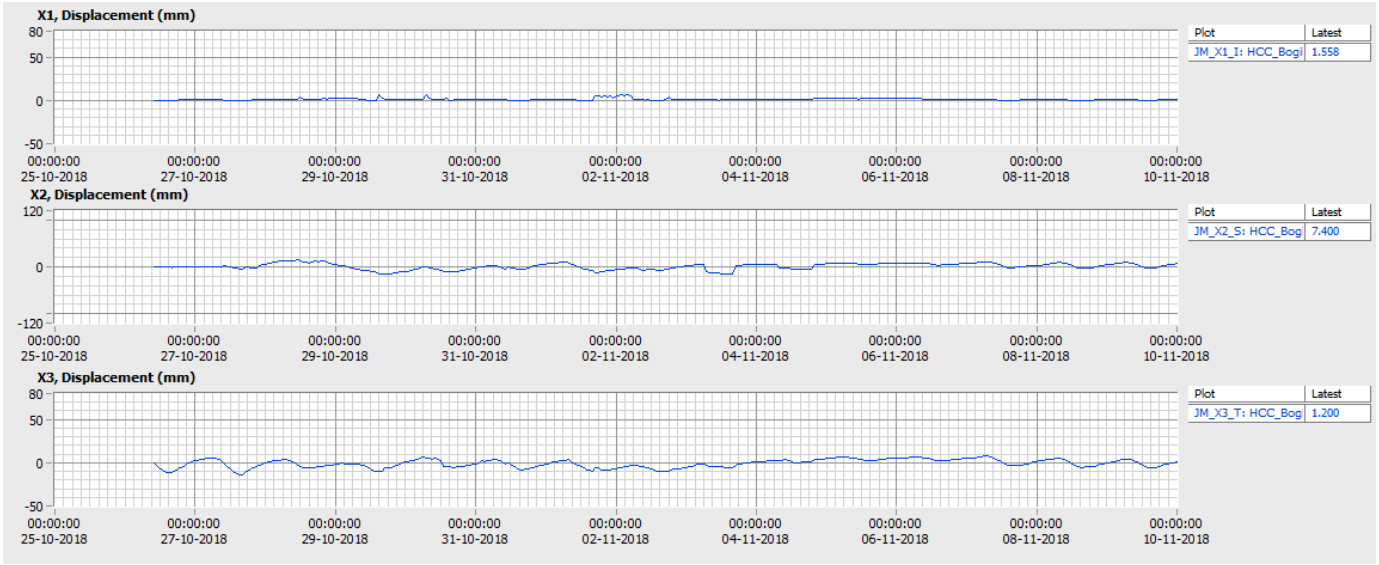
Strain gauge installed on Diagonal Chord Girder of Normal Span showing variations in strain during the Load test



Strain gauge installed on Top Cross Girder Main of Normal Span showing variations in strain during the Load test



Displacement sensors installed to measure free and fixed bearing movement and expansion joints



Displacement variations during the Load test