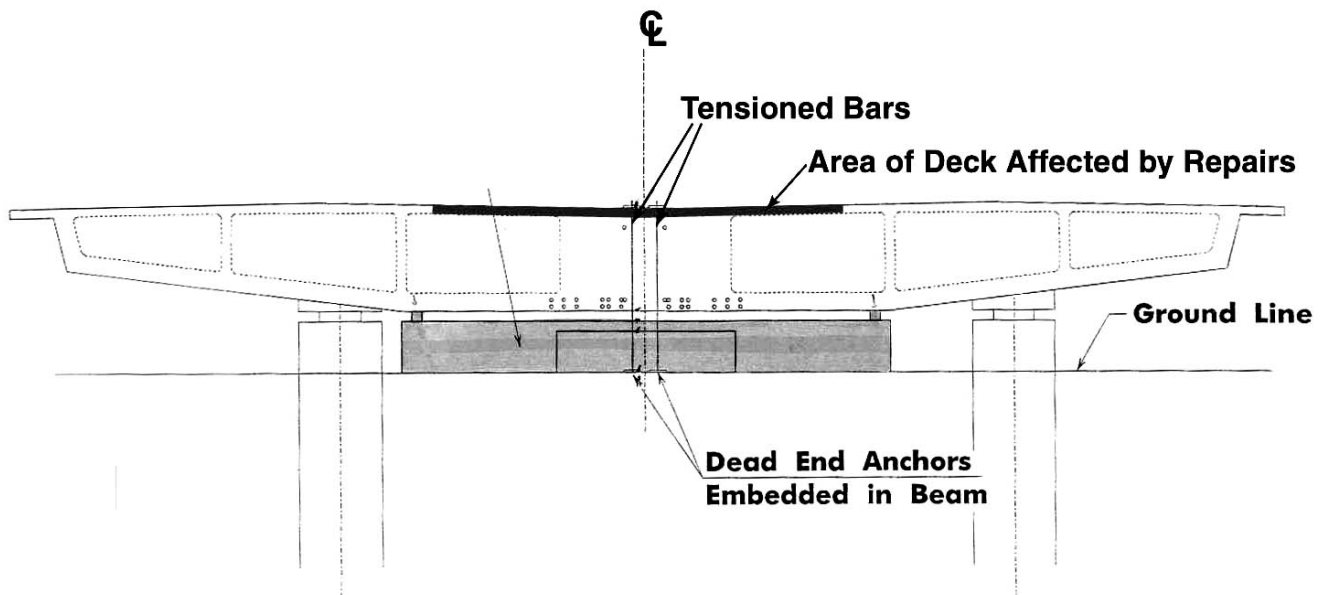


# **iSite Monitoring for Zakim Bridge Central Artery Tunnel Project Boston, MA**

The Central Artery/Tunnel Project in Boston, MA is the largest urban infrastructure project in the US. The most identifiable feature of the project is the Leonard P. Zakim Bunker Hill Memorial Bridge – an asymmetric cable stay bridge – was completed in early 2001. Prior to joining the bridge to the yet-to-be-completed tunnels, a series of cracks were noticed in the concrete bridge deck. Although minute, the cracks appeared in only a small area of the bridge. The cracks were consistent in form and direction and inferred the possible presence of excessive tensile stresses in the concrete. The CA/T performed non-destructive sonic testing that indicated the presence of voids in the concrete near the observed cracks; this was quickly confirmed with exploratory slots made in the deck.

After some deliberations it was decided that reparations were needed – it was proposed to exhume the area of concrete decking above the voids, replacing and re-spacing some of the rebar, and pouring the concrete deck again with strict adherence to best practice. The proposal included a temporary beam placed transverse to the bridge centerline and held rigidly at the center as shown in figure below. By tensioning the bars at the center the beam was forced upward against the bridge wings. The load in the bridge ‘wings’ was thereby transferred to the beam and bars, removing or reducing the tensile stresses potentially carried in the deck area to be worked on.



Eight threaded bars were fixed into the center area of the beam in groups of four; the bars were jacked tightly against the upper surface of the bridge deck at the centre and locked off.

## **Monitoring for Safety and Performance**

### **Crack Monitoring**

On discovery of the cracks, Geocomp-Brown JV (GCB) was asked to provide instrumentation to monitoring the cracks on a high frequency. Continuing work tensioning the cable stays was being performed and there was little understanding of the impact that this or other activities would have on the bridge section of concern. GCB quickly installed 8 LVDT sensors mounted; a close-up photo showing a single sensor and mounting bracket across a crack is shown in the figure below. The sensors were connected to 8-channel iSite analog loggers and monitored at very regular intervals.

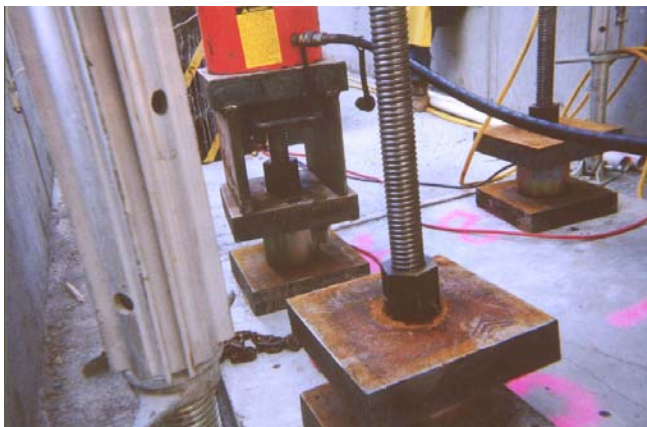
Data were collected frequently by a technician in the field using the iSite logger's built-in radio transmitter/receiver or by direct connect to the loggers. Initially the data were reported daily to the project team; the



cracks appeared to be stable with only thermal changes recorded. In October 2001, GCB linked the monitoring network to Geocomp's iSite web-based monitoring system for real-time data collection and reporting using a cell phone Portal unit – this change provided up-to-the-minute data during the preparation work for the temporary beam stressing.

### **Load Monitoring**

Monitoring for the reparations work comprised surveying on the bridge deck to measure deflection during jacking of the beam onto the underside of the bridge, and load measurements at each jacked bar using load cells.



The engineer for the reparation plan stipulated that loads after lock-off should not reduce by more than 5% of the lock-off load.

For monitoring, vibrating wire load cells were used in this instance with each vibrating wire transducer in the load cells (up to 4 in each) logged separately. The load cells were placed between bearing plates as shown in the adjacent photo. They

were connected to 8-channel iSite vibrating wire loggers and the data were automatically transmitted through a cell phone Portal unit to Geocomp's iSiteCentral web site for immediate reporting to all involved parties through the web.

During initial tensioning of the bars – and for later tensioning events – readings were collected on 5 or 15 minute intervals; these data were available on the web in near-to real-time. Readings were also requested on an 'as-needed' basis. These were made by Geocomp engineers through the cell phone portal and relayed to the site engineer via cell phone.

For the periods between tensioning, readings were taken every hour. The iSite alarm service was started on all of the loggers after the initial jacking activity. When a vibrating wire transducer reading exceeded the 5% drop-off limit, a Geocomp Engineer was immediately paged from the portal. Our engineer accessed the web, reviewed the data, and validated the readings within one-half hour of the alarm. The project engineer was then notified of the recorded change. The data at this point were all available on the web for all parties to view and analyze.

### **Outcome**

The auto-logged system was in operation for nearly 4 months and the reparation work was completed without incident. Several times during the operation the loads in the bar were adjusted to compensate for stress relaxation of the support system recorded and reported through the iSite loggers. The engineer responsible for the reparation work found it possible to work from his office in Florida and have up-to-the-minute data every morning to assess the response of the temporary support to the reparation work.

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