APPLICATION NOTE

CAS DATALOGGERS

Load Cell Monitoring of a Tunnel Jacking Operation in Real-Time

Flexible dataTaker Records Force, Pressure & Movement Thoroughly

CAS DataLoggers worked together with Custom Systems & Controls, Inc. in Framingham, MA to provide a data logging system for load cell monitoring in a tunnel jacking operation. CSC was contracted by SECAC Tunneling of Baltimore, MD to design and build a flexible data acquisition system for their project to excavate a tunnel in Quincy MA, near the Boston area. The project involved replacing the aging Town Brook Culvert, which formed a part of the ongoing revitalization of Quincy Center. Because digging a trench would be impractical, the project required tunneling underneath Hancock St, a busy thoroughfare in one of the main business districts. Utilizing a trenchless construction technology called tunnel jacking, their method used hydraulic arms to push rectangular, precast concrete tunnel sections under the roadway. Since excavation takes place from within the tunnel, it causes minimal impact on the surrounding utility infrastructure and surface traffic. During the construction, it was necessary to monitor the equipment by recording the force from six load cells, plus the hydraulic pressure, and movement of the excavation structure to thoroughly document the jacking process. Workers also needed to view real-time operational data during tunneling operations and have the capability to conveniently transfer all data to a PC for analysis.

Installation

Custom Systems installed a [dataTaker DT80 Intelligent Data Logger] in a control cabinet located on a soldier pile at the bottom of the tunnel jacking shaft. The dataTaker with 5 universal analog input channels allowed each to be configured to accept 2 differential inputs, for a total of 10 available channels. The data logger was then connected to 6 load cells, a hydraulic pressure sensor, 2 tiltmeters, and an external 12-Volt excitation power supply. The control cabinet also included a Maple Systems 7” Graphic HMI Touchscreen Display connected to the data logger for real-time viewing of all the measurements. The control cabinet was also equipped with external Ethernet connector for the logger, and a USB port which allowed data to be download to a USB stick. These ports were provided with dust covers to protect the system from dirt and debris.

Usage

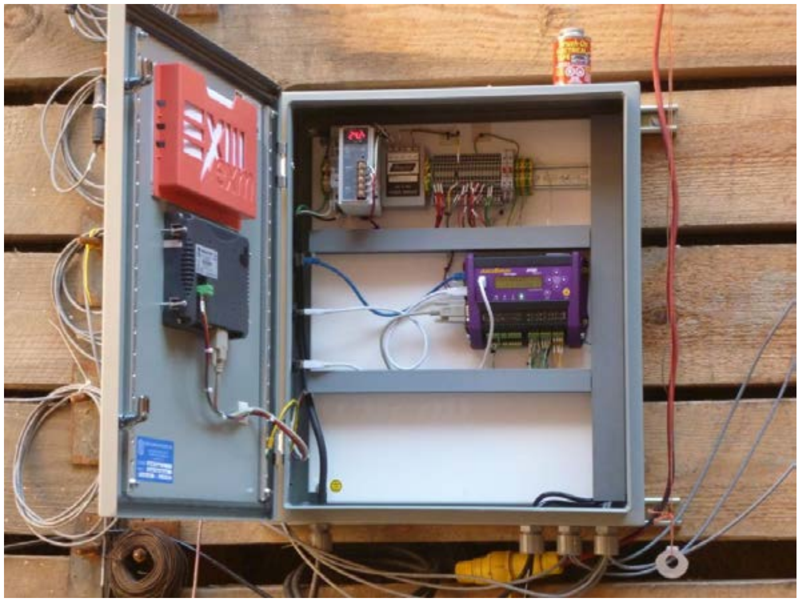
While jacking operations are commonly used in the construction of buildings, this was a novel application in tunneling. The tunnel opening measured approximately 10 ft high x 12 ft wide and was gradually excavated by the use of a boom-mounted, transverse cutting head called a “roadheader”. Spoils were removed by use of a tunnel digging machine and muck cars. As the excavation progressed, the precast concrete tunnel sections were periodically jacked forward by 4 hydraulic cylinders capable of exerting up to 800 tons of force. After the jacking cylinders were fully extended, workers retracted them and added the next tunnel section. A total of 18 tunnel sections, each 8 ft long, were required to complete the tunnel length of approximately 140 feet.

Though the amount of friction generated by the surrounding soil helped determine how much jacking force was required, it was critical to log and view the hydraulic pressure to avoid damaging the tunnel segments. In this way, the logged data was available to confirm that operators stayed within the window of safe jacking force during operations in case they needed to prove best practices afterward.

The dataTaker data logger recorded 9 important parameters during the jacking machine's operation. First, was the force on each of a total of 6 load cells, located at the top and bottom of the tunnel jacking machine, which could vary from 0 to 20,000 lbs. Second, a standard pressure transducer with a 4-20 mA output monitored the hydraulic pressure in the system over a range of 0 to 10,000 PSI. Lastly, the bottom of the 30-ft tunnel shaft, which was constructed using steel soldier piles and wood lagging, had a reaction block constructed at its base from concrete and structural steel. As the rams pushed against the block to generate its jacking force, 2 tiltmeters mounted on a nearby soldier pile logged any movement in the back wall of the shaft. The tiltmeters provided a voltage output and measured the precise tilt angle with a range of about +/- ½ a degree. Workers monitored all of the above data in real-time on the Maple display to help evaluate the excavation process, considering factors such as soil density, jacking force and more.

Operators needed to keep the jacking forces within the allowable limits during tunneling, so greased antifriction belts, which are integral to this innovative process, were used to give the tunnel sections a lubricated surface to glide on. As tunneling progressed, the belts were exposed to tension as they were partially dragged along with the tunnel section while it was being advanced by the jacks. The 6 load cells were used to monitor the tension of these 6 belts, 3 on top and 3 on the bottom of the tunnel, in order to prevent over-tensioning. Normally the belts were exposed to low tension levels averaging 300-500 lbs. However, if the tension measured by the DT80 became higher, in the range of 2,000-2,500 lbs, it indicated that the belt was being pinched and dragged. Users relied on the data logger to monitor the load cells, as formerly they had no indication of the building tension until a belt became damaged or failed. The belts looped inside the top of the tunnel, hanging from the ceiling to keep them from interfering with tunneling operations. As the tunneling progressed, more belt was pulled off the spools which were mounted outside of the tunnel.

Since connecting to a PC was rarely done as bringing one down into the tunnel shaft was impractical. Data retrieval was simplified by using the ability of the data logger to offload recorded measurements to a USB flash drive. The DT80 was also capable of Ethernet and remote data transfer if a PC was available. CSC Project Manager Vin Calio explained, “Storing the data on a flash drive makes it easy to retrieve it all at the end of each day.” Workers were also able to select between day or night (standby) mode to control sampling speed. During the day, the system logged at 1 sample a second on all channels, while in night/standby mode it only logged once every 10-15 minutes to conserve memory during times when no jacking was taking place. Collecting the data was easy--users simply plugged in the flash drive and used a soft key on the touch screen display to initiate data transfer —all without needing a PC.



Benefits

The dataTaker intelligent data logger formed an essential part of Custom Systems' integrated solution, measuring load cell, 4-20mA, and voltage signals simultaneously without requiring any external signal conditioning modules or accessories. Vin commented, "The dataTaker gives us a large feature set. We like the DT80--it is very cost-effective given all its features."

Vin also utilized CAS DataLoggers' free tech support to get a quick start on system configuration and setup. This was especially useful since the project was on a tight schedule and much of the configuration was performed in the field. Vin commented on the logger's programming: "The free support helped me get off the ground really quickly, and after taking some time with the graphical interface, it's become easy to work with."

For further information on our wide range of [dataTaker Intelligent Universal Input Data Loggers,] load cell monitoring or to find the ideal solution for your application-specific needs, contact a CAS DataLogger Application Specialist at **(800) 956-4437** or www.DataLoggerInc.com.