



REAL TIME MONITORING OF CITYRAIL TUNNELS, SYDNEY WHILST CONSTRUCTING A 14 STOREY BUILDING DIRECTLY ABOVE

A 14 storey development with two basement levels has been constructed immediately above four CityRail tunnels between Town Hall and Wynyard stations, Sydney. PSM were engaged by the developers to analyse the impacts of the proposed basement excavations on the underlying tunnels and to design footing systems so as to constrain stress changes in the tunnel linings to RailCorp criteria. RailCorp also required that a monitoring system be established in the tunnels to measure deformations, opening of existing cracks and any development of new fractures in the linings.

PSM decided the best approach would be to install a real time monitoring system as well as undertaken weekly tunnel inspections.

Crackmeters and tiltbeams were installed in the tunnels, in locations considered most likely to react to basement excavation and tower loadings. One zone in particular where monitoring devices were concentrated was within the GPO Fault Zone, which occurred in the western half of the site.

Real Time Monitoring

The following diagram provides the conceptual automated real time monitoring design. PSM designed the system with a back up such that there would be control of the data in case of problems, via use of a virtual network connection (VNC), with the monitoring laptop on site connected to the internet. If problems with the automated real time monitoring system occurred, a back up system of audible and visible alarms was available.

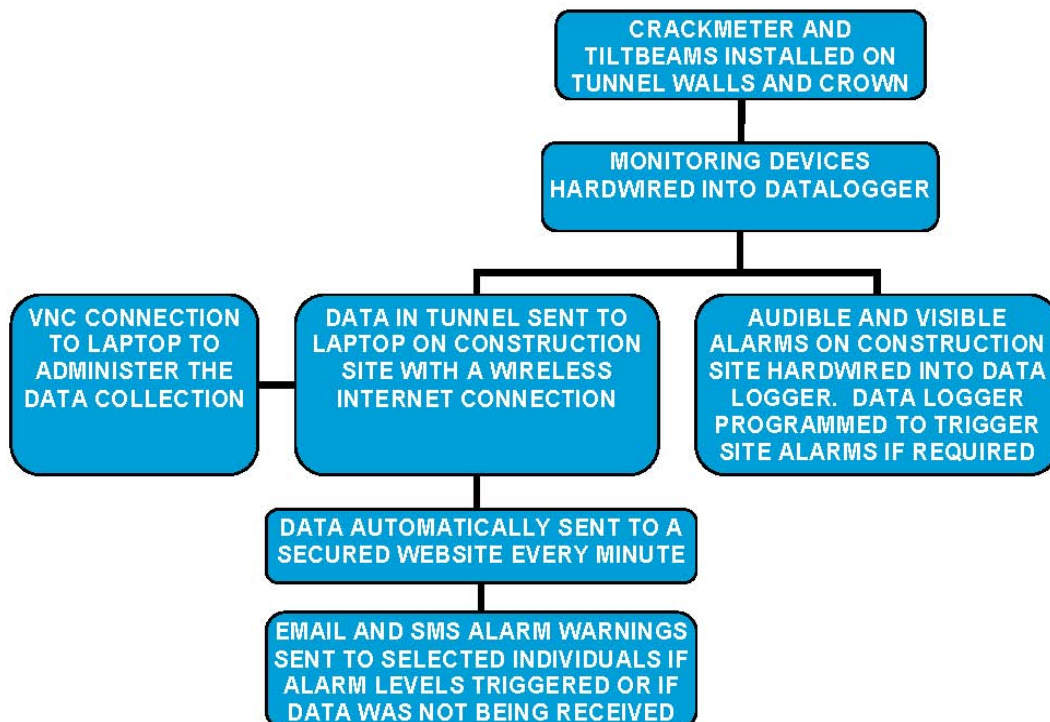




Figure 1 show a simplified plan of the site with monitoring locations superimposed. If the monitoring devices started reading within predefined alarm states, then the green dot would change colour to the corresponding alarm state on the computer screens.

Figure 2 shows a plot of devices within one of the tunnels and Figure 3 shows a time displacement plot of the same tunnel.

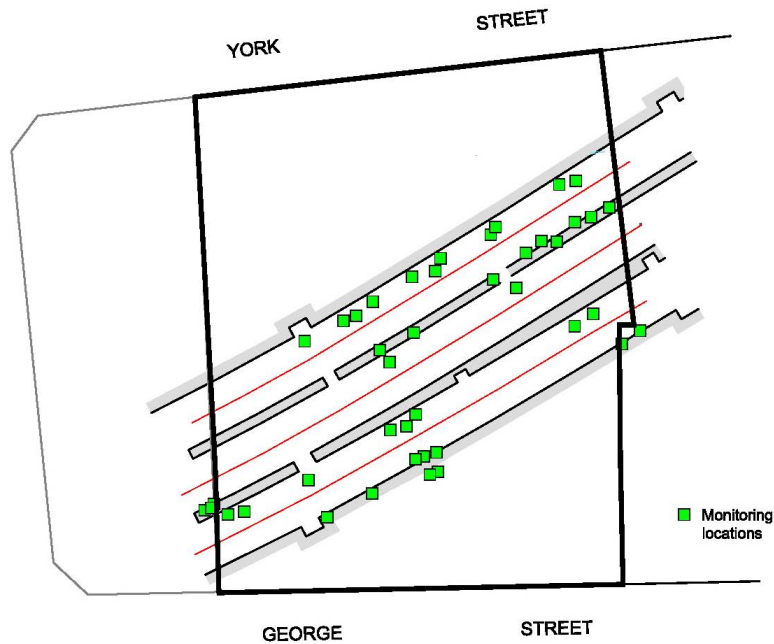


Figure 1 Plan showing real time monitoring locations, the upper three tunnels, the construction site and the location of the GPO fault zone.

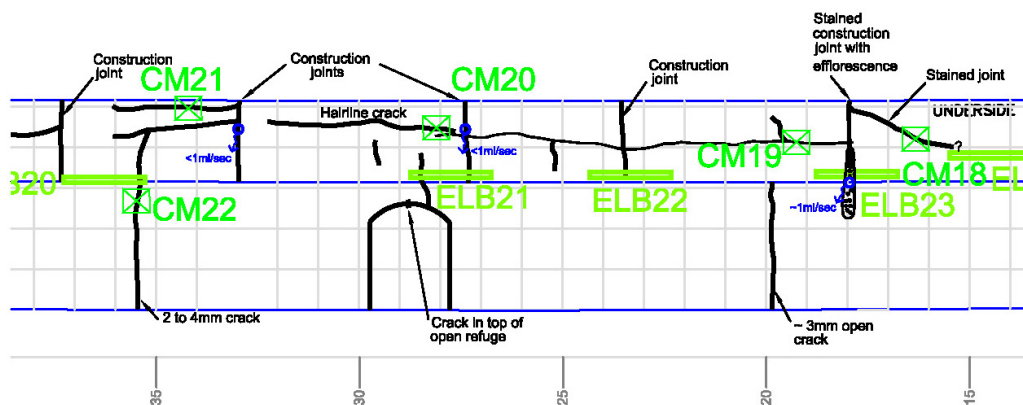


Figure 2 Section showing monitoring devices installed in the western tunnel.



Figure 3 Time displacement plot of devices installed in the western most tunnel.

In total, 53 automated real time sensors were monitored every minute, collecting about 75000 data points per day and in excess of 40 million data points over a 19 month period. Although the monitoring system was automated, general maintenance of the database such as archiving and downloading data for additional manipulating was carried out on an as needed basis.

What happened if an alarm was triggered?

Occasionally, the devices would return false readings, attributed to electromagnetic energy from passing trains affecting the measurement. The false readings would occasionally trigger and alarm whereby warning emails and SMS messages were sent to relevant personnel. When these warning messages were received, PSM personnel, via use of the VNC connection, were able to look at the raw data being sent from the data logger to establish whether the warning was real or false.

Fortunately for all project stakeholders, including

train users, no real alarms were triggered. Of the 40 million data readings collected, about 0.001% were false readings, less than half of which actually triggered an alarm.

Commentary

Automated real time monitoring proved to be valuable in this situation as it provided a level of comfort for all the project stakeholders. The real time system that was implemented, enables the collection of almost unlimited data, readily accessible via a secured website to relevant personnel. This particular set up, not only provided significant cost savings compared to conventional monitoring solutions but provided real time knowledge of the deformation that the CityRail tunnels were experiencing. The setup that PSM designed can easily be adapted to a whole range of applications, including monitoring of excavations, slopes, civil infrastructure and so on.