Student SURVEY Expeditions

Deformation Monitoring: Investigation of the magnitude of thermal expansion on the Niagara Dam wall.

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History

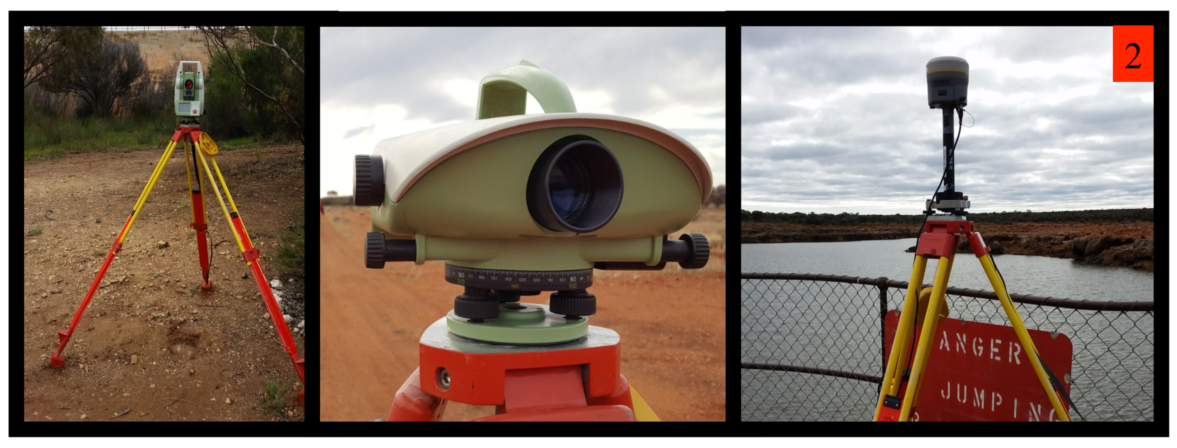
The Structure observed as part of the deformation monitoring campaign, Niagara Dam (Figure 1), is a brick dam wall originally built by hand in 1897-1898 costing of $128,000. Niagara Dam is 228 Meters long, 18m high and is capable of holding 141,00 cubic litres of water at maximum capacity. Niagara Dam is located 10km south of Kookynie (Northwest of Kalgoorlie) in the Goldfields of Western Australia. The intended purpose of Niagara Dam was to supply fresh water for the gazetted Niagara Town site and also for the locomotives that would steam along the railway linking Kalgoorlie and Malcom. The dam itself was made redundant soon after being established due to a large amounts of ground water being discovered nearby at Malcom itself and unpredictable and poor rains often left the dam near empty.

Aim:

Deformation monitoring is an important task taken upon by surveyors to determine the magnitude of displacement effecting long term structural stability. Deformation monitoring provides data which can then be used by engineers to verify structural safety design parameters and update regular inspection reports. Dams walls frequently experience deformation due to a number of forces resultant of internal and external forces e.g. Stress caused by the weight of embankments and water loads. The aim of this project was to determine the magnitude of elastic deformation(deformation reversed when force is removed) caused by thermal displacement over the 24hr period of a day by employing traditional monitoring techniques(Figure 2) including:

- terrestrial observations(observed using a Leica TS15 Total station) from a stable network of reference marks to signalised object points located on the surface of the dam wall(observed every 15 minutes),
- precise levelling to points located on the top of the dam wall(observed every hour)
- a 24 GNSS baselines to verify the trends observed the two primary methods.

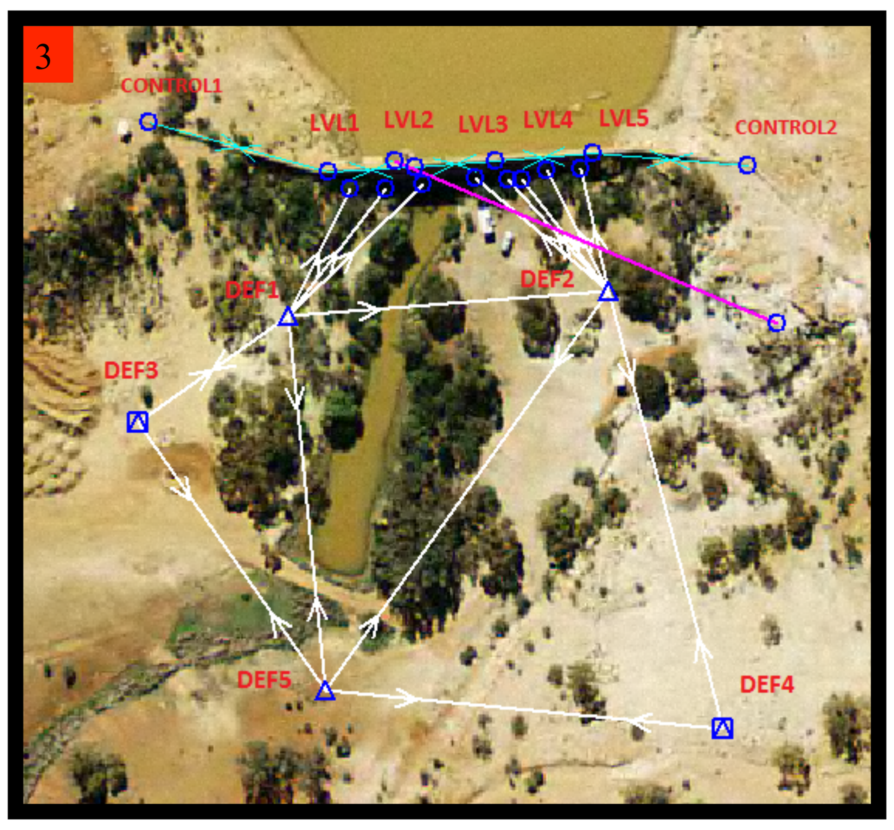
Due to the remote location of the study object, pre-planning was vitally important to ensure precision requirements could be met due to the small magnitude of expected deformation, this resulted in a flexible network design allowing for changes due to location restrictions.



Established Monitoring Network:

The Network Established at Niagara Dam consisted of (Figure 5):

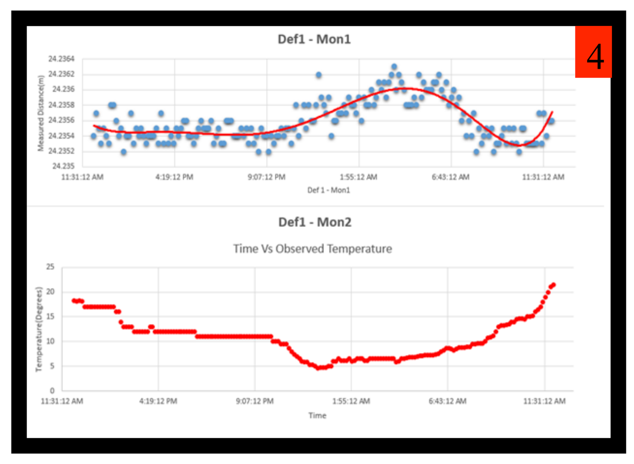
- 5 reference stations and
- 8 monitoring stations on the dam wall were established at the survey location (Figure 3).
- 5 Levelling stations across the top of the dam wall.



Analysis Methods:

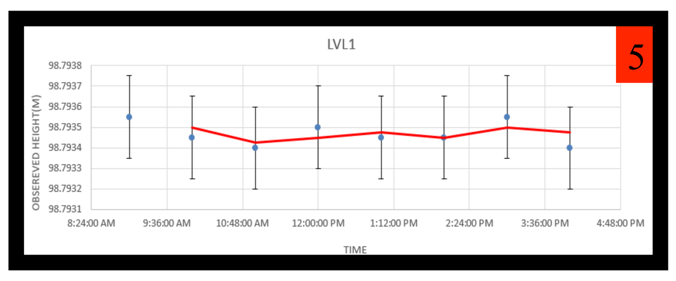
Network Deformation Analysis Consisted of:

1. **Stability analysis:** using methods including global congruency testing to determine the stability of the reference marks throughout the monitoring campaign, whereby all marks were deemed to be stable throughout the monitoring period.
2. **Individual point testing** as part of a two epoch analysis was then completed on two epochs were the magnitude of displacement was deemed detectable as determined by from analysis of the changes to the measured distances over time (Figure 4). Individual point testing is used to determine the magnitude of deformation at the object point, by performing local congruency testing, which essentially asks, has there been a significant change in position of the points given the precision at which they were observed?



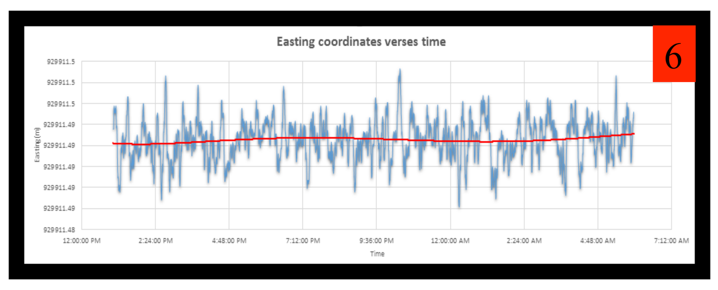
Precise Levelling Analysis Consisted of:

1. Plotting time verses observed heights then determining if the magnitude of change was greater the observational precision(Figure 5).



GNSS Baseline Analysis consisted of:

1. Computing a kinematic baseline solution
2. Applying averaging filters to the baseline results to remove noise
3. Plotting a time series of observed baselines (Figure 6)
4. Trend analysis to determine if any significant displacement trends are present.

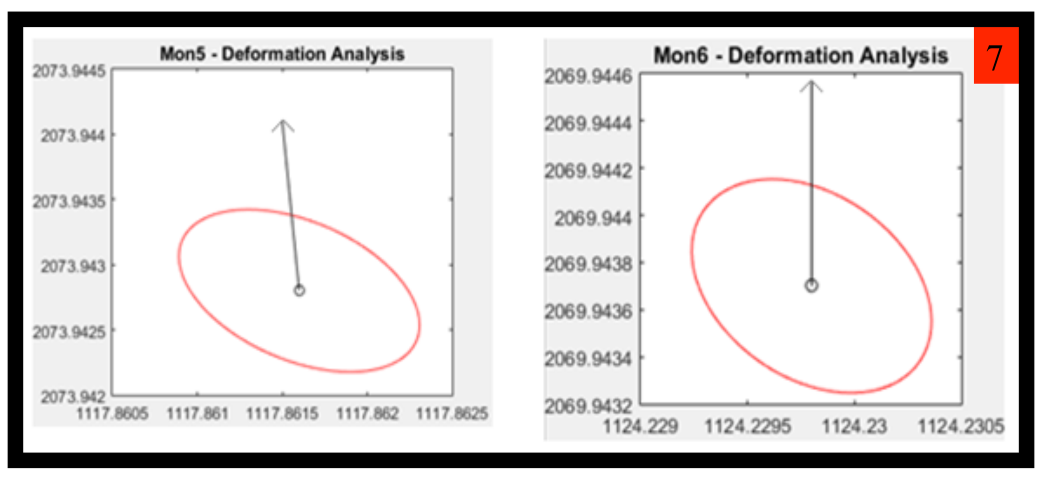


Results:

Deformation Network Results
Deformation was deemed detected, if the magnitude of displacement was larger than the combined precision from the two epochs (Figure 7). As a result an average of 1.2mm ±0.8mm(over the temperature range 4°- 16°) of at each of the 8 object points has been detected over the 24hour period. To determine the accuracy of these findings, the linear thermal expansion of a theoretical dam wall similar in size to Niagara dam was determined using the coefficient of concrete ($12.5x^{-6}$ m k). This resulted in a similar displacement value of 1.04mm, confirming the trend observed at Niagara Dam.

Precise Levelling
From the precise levelling insignificant vertical displacement determined, with changes in the height of most levelling stations being 0.2mm between epochs being less then the observational accuracy of the Leica DNA03 (±0.3mm).

GNSS Results
From the processing competed thus far, no trends have been identified in terms of horizontal or vertical movement.



Acknowledgements

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