Innovation from Disaster - Applying 3D Laser Scanning Technology to Earthquake Recovery Projects

Andrew SINCLAIR, New Zealand

Key words: Deformation measurement; Engineering survey; Laser scanning; Reference frames; Young surveyor

SUMMARY

A large proportion of the survey work to follow the Canterbury Earthquake sequence has been damage assessment so that appropriate repair strategies can be implemented with confidence. The assessment and design process has been aided by the ability of recent measurement technology to capture a large amount of data in a short time.

I have been fortunate to be involved with a new innovative workflow for these projects at a time when 3D Laser Scanning technology has become the new standard in the rebuild. A high resolution 3D point cloud is able to be seamlessly integrated into design software with the coordinate system intact. Modelling and subsequent design can occur and any site fabrication can be set out precisely in terms of the project coordinate system.

Use of 3D Laser Scanning has enabled us to collect more data quickly, present results in greater detail, and afford more confidence in the subsequent analysis, design and fabrication.

I will demonstrate several case studies including:
Early projects - Christchurch Arts Centre, Christchurch Cathedral
Infrastructure repair - brick barrel culvert proximity to rail tunnel repairs
Historic infrastructure as-built - potholing, scanning, modelling, design
Building deformation - building verticality, under floor assessments
Foundation assessment - measurement of existing piles

Innovation from Disaster - Applying 3D Laser Scanning Technology to Earthquake Recovery Projects

Andrew SINCLAIR, New Zealand

1. INTRODUCTION - MY EXPERIENCE WITH THE CANTERBURY EARTHQUAKES

Figure 1 - Eliot Sinclair Office, Level 5, 151 Kilmore St

- Our Kilmore St office was structurally damaged and subsequently demolished
- We moved to Wairakei Rd office near airport – shared space with a car rental company
- I had already purchased flights to Switzerland snowboarding – left 2 weeks after Feb 22 quake
- Arrived back to work to 3D Laser Scanner – Arts Centre project

2. A FIELD SURVEYOR’S PERSPECTIVE ON SCANNING

Figure 2 - Trimble FX Scanner (2011)

- An exciting new tool to master
- New computer software/ hardware required to handle very intensive processing and large datasets
- A need for robust quality control in the field and office
- Big learning curve
- Now in 2016 we operate 3 scanners and a Quad-copter
- Focus on geospatial framework for repair and rebuild

3. CHRISTCHURCH ARTS CENTRE - OUR INTRODUCTION TO SCANNING

Figure 3 - Historic Arts Centre

- Providing data to project team of modellers, engineers, architects.
- Capability to gather millimetre accurate 3D model of existing damage
- Temporary steel structures established for continuing quakes
- Individual stones could be modelled, taken down and labelled
- The structure repaired, stones put back in original pattern
- Project is now half way to completion
- We have had repeat visits to collect extra details as needed, and to provide setting out in the project coordinate system

4. CHRIST CHURCH CATHEDRAL – AN ICON

Figure 4 - Christ Church Cathedral (Rose Window Collapsed)

- Scanned to form a dataset for heritage purposes
- After Feb 2011 quake had destroyed rose window
- Structural damage – health and safety limited time inside

5. INFRASTRUCTURE REPAIR – WHAT IS BEHIND THE WALL?

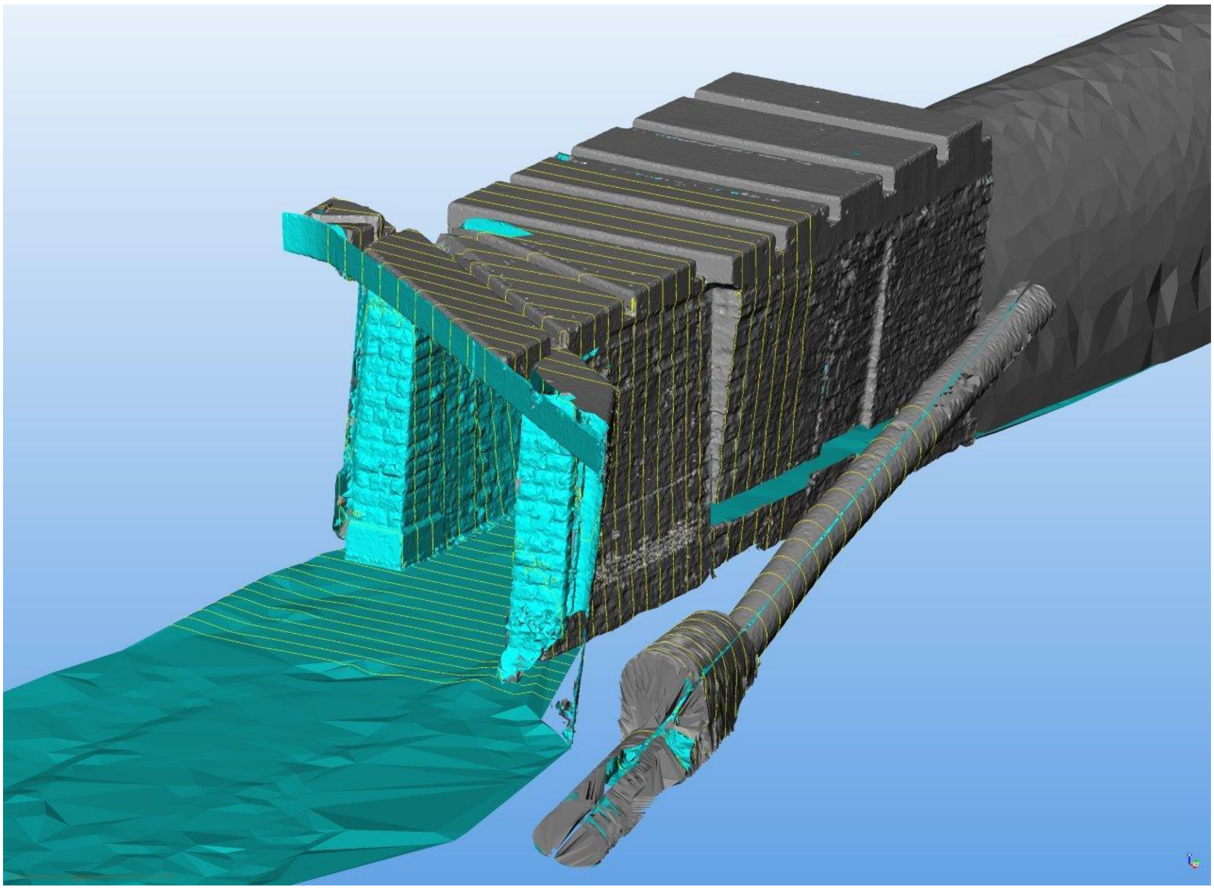

Figure 5 - Historic Culvert Proximity to Rail Portal

- We were asked to undertake a topographical survey and scan of the entrance to a rail tunnel
- Detail scan needed of distorted retaining wall
- The engineering team identified a repair strategy using tie-back rods to be drilled through the wall into the bedrock behind
- Historic records showed a brick barrel culvert (storm water pipe) in the vicinity
- No accurate record of its 3D position
- Solution was to scan the inside of the pipe using our small FARO laser scanner
- Scanner operated by a commercial diver on radio with video link
- Extra scans at manhole and common targets for control
- We produced a 3D model of the culvert and chamber to an accuracy of +/-10mm
- Tie-back rods were designed to accommodate the close chamber
- Setting out was undertaken in relation to our fix of the retaining wall

6. HISTORIC INFRASTRUCTURE IN THE CITY CENTRE – SCAN, MODEL, CLASHES

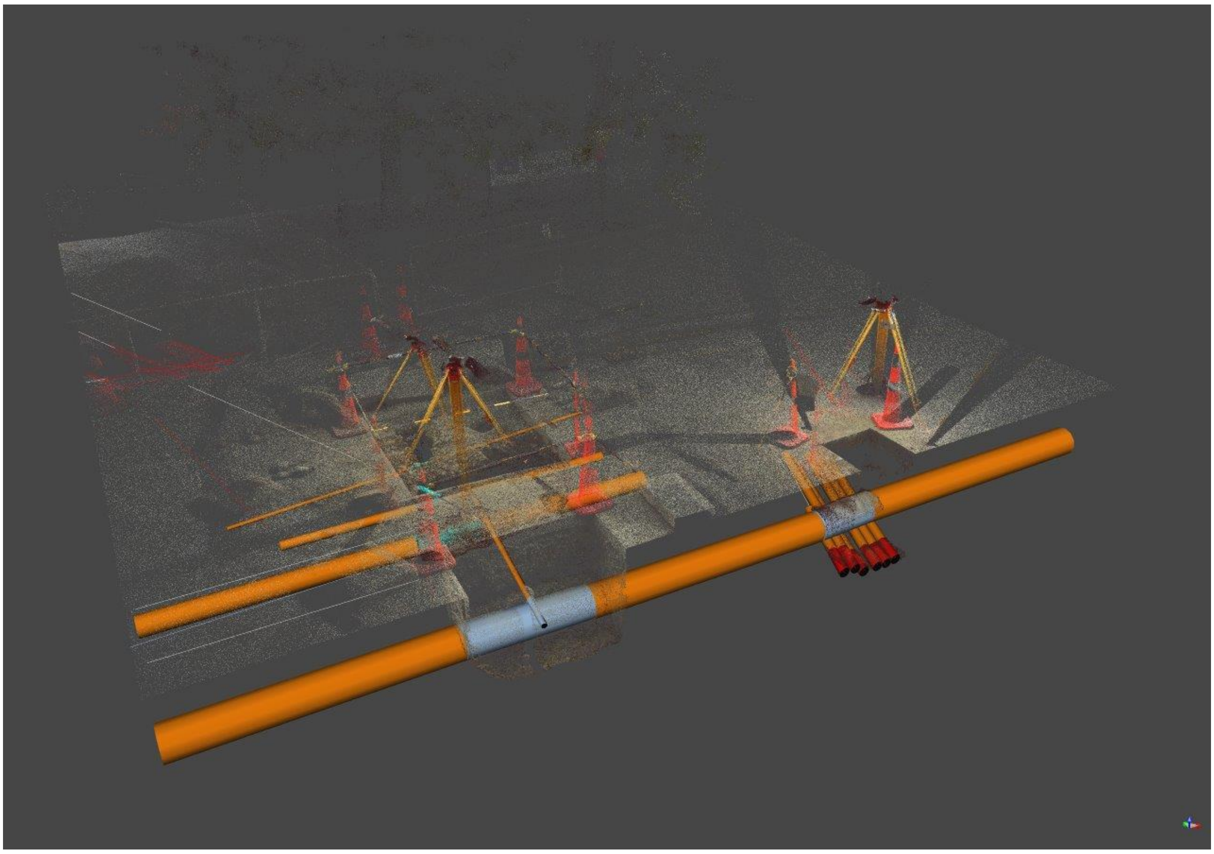

Figure 6 - 3D Modelling of Underground Services through Potholes

- We were approached by a design team working on new underground services in the CBD rebuild
- Concerns about clashes – potholing would be undertaken
- Needed ability to modify design where needed to avoid existing utilities
- 100 year legacy of utilities with poor records – no depths, plans for some services only
- We created a workflow to scan the existing services in the open potholes, model the pipes etc. with included attributes (utility owner, material etc.), and provide models to the design team for integration into their project.
- Attention was given to achieve the ideal file type to ensure no loss of attributed data
- Common geospatial framework was critical
- This was achieved through survey control incorporated to register the scans and models in the project coordinate system

7. BUILDING DEFORMATION SURVEYS – MORE DATA = MORE CONFIDENCE

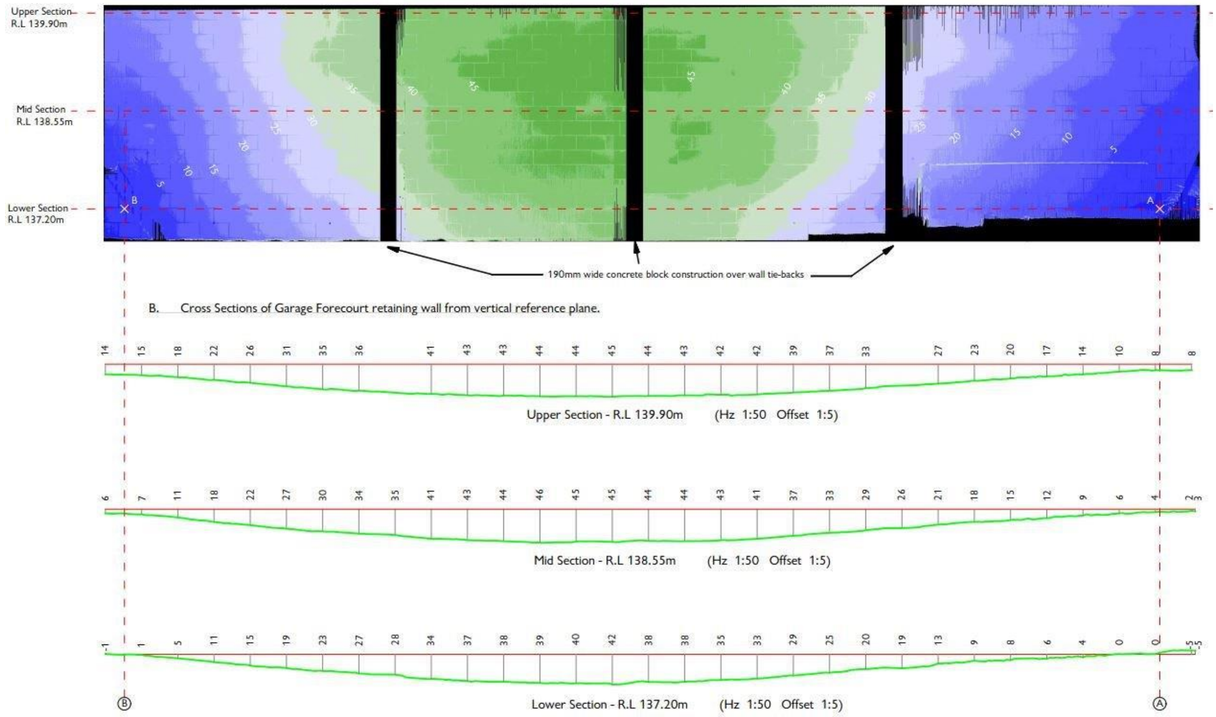

Figure 7 - 10m Wide Retaining Wall Under Load (Showing Distortion)

- An important part of any building repair strategy has been an analysis by a structural engineer. What is the earthquake related damage?
- Assessments of damaged buildings are done at varying levels of detail. When a surveyor is involved, it is important to present accurate floor level and wall verticality information in a clear format
- Traditionally our Total Station surveys are presented as colour contour plans and two-point wall verticality labels
- Scanning can provide enhanced deliverables such as wall displacement maps, where a point cloud of a wall is compared to a vertical plane, affording more information
- Detailed cross sections can show trends through walls across a building
- Scanning captures everything in the line of sight – door and window frames, bench tops, ceilings etc. – plus scanner photography provides a further record
- Scanning also enables capture in limited spaces – i.e. under floors

8. FOUNDATION ASSESSMENT – ACCURATE MEASUREMENT IN A TIGHT SPACE

Figure 8 - Pier Cap and Pile Location Survey

- As part of a structural assessment, our client needed to drill through the centre of existing concrete piles, invisible beneath a pier cap.
- A portion of the sides of the piles were exposed by hand digging
- We set up our scanner below ground level and scanned the visible pile surfaces
- Control was incorporated above ground
- We modelled the piles and returned the next day to set out the calculated pile centres on top of the pier cap

9. QUALITY CONTROL – WHAT THE SURVEYOR BRINGS TO SCANNING

- We have witnessed a dramatic progression of scanner technology
- We have experienced problems with corrupted scans, environmental conditions and systematic hardware failures
- Routine baseline checks at our car park pillar
- Emphasis on staff training, QA standards and documentation
- Custom scan vehicle fit out
- Control integration with Total Station, GNSS, Precise Levelling

10. GEOSPATIAL FRAMEWORK – A FOUNDATION FOR BIM

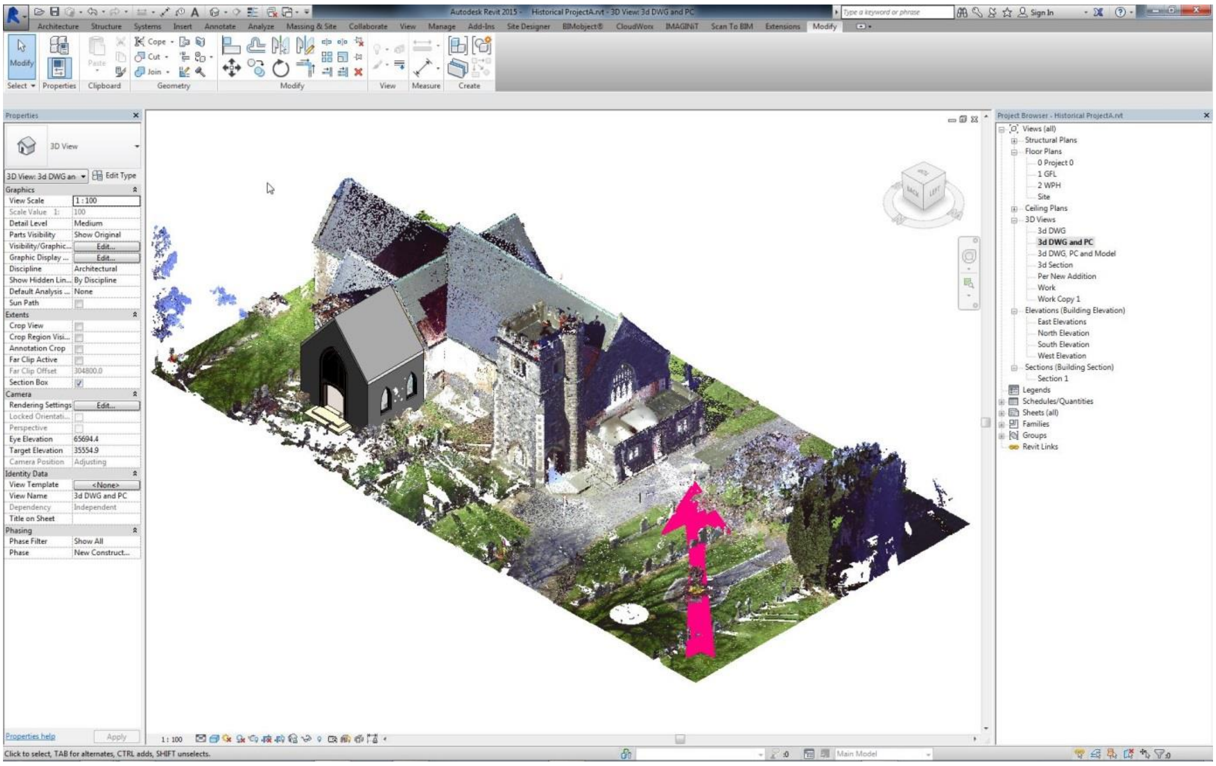

Figure 9 - Topographical Survey DWG and Point Cloud in an Autodesk Revit Environment (with Origin Survey Mark Shown)

- Every project we approach has ‘future-proof’ survey practise applied
- Always leave survey marks behind (on recognised datums)
- Focus on ease of use by the next user
- We have an architect/ BIM specialist on staff
- Geospatial information is well documented – key to simple transfer between survey (Mt Pleasant 2000) to architectural coordinate system (0,0)
- Simple to return to site for setting out or to capture additional information

11. CONCLUSION

Figure 10 - Leica P40 Scanner (2015)

- Scanning is a technology that has become very affordable and accessible – not just for surveyors and spatial professionals
- Manufacturers have focussed on providing a simple solution that is capable of being operated by any untrained person to deliver a highly accurate and dense point cloud
- We have seen equipment failures and environmental limitations
- Field and office techniques including types of targets, target geometry and registration methodology will all influence the quality of results
- To ensure data integrity in projects with no room for error, a geospatial specialist is required to employ robust quality assurance

REFERENCES

(Written from the author's experience)

BIOGRAPHICAL NOTES

Andrew Sinclair is a Licensed Cadastral Surveyor at Eliot Sinclair and Partners Ltd in Christchurch. Andrew graduated from Otago University with a Bachelor in Surveying in 2006. With a background in cadastral, topographical and monitoring surveys and a keen interest in scanning technology, Andrew has been involved throughout Canterbury in the earthquake response and rebuild.

CONTACTS

Mr. Andrew Sinclair
Eliot Sinclair and Partners Ltd
PO Box 9339
Christchurch 8149
New Zealand
Tel: +64 3 3794014
Email: ajs@eliotsinclair.co.nz
Website: www.eliotsinclair.co.nz