SCIRT Rebuilding Infrastructure

LEARNING LEGACY

Lessons learned from one of New Zealand's most challenging civil engineering projects: rebuilding the earthquake damaged pipes, roads, bridges and retaining walls in the city of Christchurch 2011 - 2016.

Retaining Wall Assessment and Prioritisation Paper

Story: Retaining Wall Assessment and Prioritisation

Theme: Design

The paper shares the process followed for the assessment and prioritisation of the retaining walls within the Port Hills in Christchurch.

This document has been provided as an example of a tool that might be useful for other organisations undertaking complex disaster recovery or infrastructure rebuild programmes.

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ASSESSMENT AND PRIORITISATION OF THE RETAINING WALL REBUILD IN CHRISTCHURCH AFTER THE 2010/2011 CANTERBURY EARTHQUAKES

Philip Wilkins, MIPENZ, CPEng, IntPE
Senior Structural Engineer, Seconded to SCIRT from Beca Ltd.
Beca Ltd., PO Box 13960, Christchurch 8141, New Zealand

Abstract

The Canterbury Earthquake Sequence (CES) of 2010/2011 resulted in extensive damage to the Christchurch City Council infrastructure assets. The Stronger Christchurch Infrastructure Rebuild Team (SCIRT) was established in response and tasked with the assessment and repair of the earthquake related damage in Christchurch to publicly owned horizontal infrastructure, including retaining walls.

This paper shares the assessment and prioritisation philosophy especially created for the approximate 1000 retaining walls within the Port Hills, including the use of a multi criteria analysis tool in assisting the rebuild programme. The paper includes lessons learnt during the early data collection stages with the collation from various sources of earthquake damage investigations, the importance of quality asset information (completeness and standardisation of key data), and the benefits of data management through Road Assessment and Maintenance Management (RAMM). The lessons learnt will assist road controlling authorities and councils in managing their assets, and will illustrate the importance of early data capture as opposed to during the challenging times of a post disaster event.

Keywords: SCIRT, retaining walls, earthquake, asset assessment, prioritisation, Christchurch

Introduction

Christchurch's retaining walls on the Port Hills were subjected to very strong ground motions during the CES throughout 2010 and 2011. The most significant retaining wall damage resulted from the 22 February 2011 (Mw6.2) and the 13 June 2011 (Mw6.0) events, which had epicentres located directly beneath or adjacent to the Port Hills.

In response to the initial earthquake on 4 September 2010 (Mw7.1), the Council set up an Infrastructure Rebuild Management Office (IRMO) to manage the reinstatement of infrastructure and oversee repairs. The situation changed on 22 February 2011, when another earthquake struck causing much more widespread damage. It was recognised that the model was no longer suitable and a different approach was required through the establishment of the SCIRT alliance. This alliance comprises of the New Zealand Government (Canterbury Earthquake Recovery Authority (CERA), New Zealand Transport Agency (NZTA) and the Council), and five civil contractors (Delivery Teams). SCIRT is supported by an integrated design office of engineers from 14 local engineering consultancies. SCIRT is tasked with the assessment and repair of earthquake damaged publicly owned horizontal infrastructure, creating a legacy of earthquake resilient infrastructure, whilst also providing value for the client organisations.

There are more than 2,500 retaining walls associated with the Council roading and residential properties in the greater Port Hills area. SCIRT's scope included the earthquake condition assessment of around 1000 Council retaining wall assets. Following this assessment, a prioritisation score was developed for each wall which was used by SCIRT's clients to select and prioritise the repair of 440 walls which were included in the SCIRT rebuild programme.

This paper shares the condition assessment and prioritisation philosophy to establish the SCIRT rebuild programme of retaining walls. The lessons learnt highlighted through this work will assist road controlling authorities and councils to better manage their assets. For further information regarding severity and typical failure mechanisms of retaining wall damage in the Port Hills refer Stone et al., (2015).

Figure 1, An example of earthquake related damage to retaining walls.

The SCIRT Design Process

The SCIRT design process is summarised in Figure 2. A project is initially defined through a condition assessment of an asset and understanding the extent of earthquake related damage. The project is then prioritised and passed to one of the four design teams to develop through the concept and detailed design stages. The SCIRT model allows early involvement of all parties involved through the design and construction stages which was extremely beneficial for identifying and managing of risks.

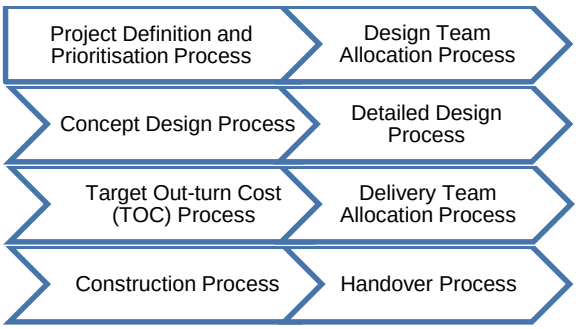

Figure 2, SCIRT design process summary.

This paper concentrates on the asset assessment and prioritisation process discussing the lessons learnt.

Condition Assessment

Prior to the Canterbury earthquakes, the Council had limited information on their retaining walls which was stored predominately on a spreadsheet. RAMM software was being trialled but this was in its infancy. Council retaining walls were only documented with minimal monitoring and understanding on their condition.

After the 4 September 2010 earthquake rapid condition assessments were undertaken through emergency response and walls "made safe" for public safety. Key projects were identified and design and delivery initiated through the IRMO process. At the same time engineering consultancy firms were appointed by the Council to both survey the number, and assess the condition of the retaining walls within the road corridor. This was the first time a comprehensive study of all the walls within the road corridor had been undertaken, identifying around 2,500 walls.

All the retaining wall information, from various sources and formats, gathered by IRMO was collated through the SCIRT condition assessment and project definition process. As a result of further earthquakes this data required ongoing reviews to validate the process. The RAMM software package was used to store the main attributes (type, height, length, condition etc.) of the walls. Collating all the information within RAMM was extremely beneficial with managing and manipulating the data. Having a "one stop shop" for data entry both in the office and in the field, through Pocket RAMM, provided a transparent system. The data could also be easily exported and manipulated to the SCIRT GIS to clearly show damage levels, responsibility and interrelationships with other projects. A spreadsheet was used to calculate the prioritisation score, however with additional time this would have been better managed within RAMM.

If the utilisation of RAMM was undertaken earlier, even prior to the earthquake events, time could have been saved with managing

the retaining wall data. Also, further systems within RAMM could have been more utilised after the earthquake events, for example the allocation of RAMM projects to the walls. SCIRT's role was not to manage the retaining wall assets but to identify, prioritise and recommend earthquake related repairs to its clients. As part of this process it was fundamental to understand the number of earthquake damaged council walls, and RAMM provided the process to facilitate this work.

Field Work

From previous retaining wall condition assessments there were varying descriptions of wall types, materials, condition etc. A systematic and consistent approach was developed assessing the walls in the field. A short report was written to provide clarity to the main wall attributes. For example: a mini crib, single crib, double crib wall was simplified to crib. The condition rating of each type of wall was also defined through a description and photographs.

Figure 3, Example of condition rating for a stone facing wall.

The report provided clarity and consistency with data capture. This was particularly important as the condition rating of the wall was to identify earthquake damage and not normal wear and tear, poor construction etc. For example a condition rating pre-earthquake of "Poor" for a wall may be "Good" depending on the extent of earthquake damage.

Data was updated in the field using Pocket RAMM. Pocket RAMM enables RAMM to be used on a netbook, laptop or tablet whilst mobile.

Entering data whilst in the field through Pocket RAMM was significantly beneficial including minimising re-entry of data in the office, managing consistency in data capture through the use of drop down boxes etc. Identifying all walls, whether private, council or joint responsibility, assisted in locating walls and provided clarity to enquiries. Training is required on the use of Pocket RAMM and understanding the intent of the assessments.

Figure 4, Utilising Pocket RAMM during the condition assessment of retaining walls.

Responsibility

Determining the responsibility for the repairs of the retaining walls was a significant factor for the SCIRT retaining wall rebuild programme. The walls were broadly categories into Council, private or in some circumstances joint responsibility.

The process of determining who is responsible for a wall is, in some cases, quite complex, with the outcome potentially having substantial financial implications for those ultimately responsible for the repair/rebuild of the wall. This is of particular importance for the older retaining walls, like those within Lyttelton, which are generally not engineered

and have not been maintained, and which have very little indemnity value.

The Council took a legal review of its obligations and responsibility for retaining walls across Christchurch. Through this review process the number of walls the Council has responsibility for significantly increased. The subsequent implementation of this review resulted in budgetary uncertainty and additional pressures for both the Council and private owners during the challenging times of the emergency response and rebuild stages post-disaster.

To assist with the process of determining the responsibility, and provide clarity to residents, a leaflet was produced by the Council answering frequently asked questions (Christchurch City Council, 2013).

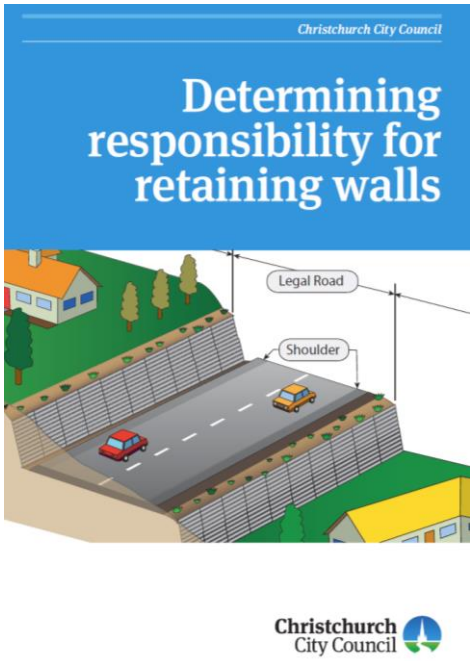

Figure 5, Front cover of retaining wall leaflet on determining responsibility produced by the Council.

The leaflet highlights that determining the responsibility for a retaining wall depends on a number of factors including the following:

- Whether the retaining wall has been built within the legal boundaries of a road or on private property.
- Who ultimately benefits from the construction of the retaining wall i.e. support of Council asset or private asset.

For both councils and private owners it is fundamental that the responsibility of the repairs to the retaining walls is clearly identified. The necessary arrangements can then be made to facilitate the reconstruction and understand insurance policies and entitlement.

The process of determining the responsibility of a wall can be better managed out of the emergency response and rebuild stages. A coordinated and systematic approach can be effectively communicated and the network managed appropriately.

Prioritisation

Following the condition assessment, SCIRT and the Council developed a prioritisation score process for each retaining wall considering operational, external and delivery prioritisation. These three prioritisation processes are discussed in more detail below. This prioritisation score was used to select and prioritise the repair of the 440 walls which were included in the SCIRT's rebuild programme.

Operational Prioritisation

A Multi Criteria Analysis (MCA) tool based on structural engineering principles and field data analysis was used to assign retaining walls an individual operational priority score. Specific attributes with assigned values were used to calculate a prioritisation score; wall type and level of damage (likelihood) multiplied by wall height and consequence of failure (consequence). The development of the MCA tool required a degree of judgement both with attributes used and allocated weightings. To verify the assumptions made data sampling was undertaken to review and calibrate the model.

External Prioritisation
Other factors influencing the order of the retaining wall rebuild programme, which were determined in conjunction with SCIRT's clients, included the following:

- Geographical proximity with other horizontal infrastructure assets so to achieve a "one pass" approach where practical. SCIRT's GIS was used extensively to ensure these dependencies were well understood and defined.
- Proximity to Medical and Emergency, Schools, Hospitals and key Transport links (MESHT) to ensure services are maintained to these important facilities.
- If the wall is on a critical lifeline route which would isolate properties causing significant issues for the affected communities.
- Land zoning decisions
- Mass movement areas
- Properties which are uninhabitable (S124 notice issued) until retaining wall repairs are undertaken.

These external factors were weighted appropriately and included in the prioritisation MCA tool. The allocated weightings ensured that protecting life and critical lifeline routes remained the priority focus for the wider community benefit.

Delivery Prioritisation
SCIRT initially adopted and managed the design and construction of key projects, consisting of predominately individual walls, from IRMO. With the large number of Council walls which required repairing or rebuilding a different, more global, approach was developed.

The remaining walls were geographically grouped and allocated a specific design and Delivery Team to each area. This provided multiple benefits including consistency in design, communication and value engineering opportunities.

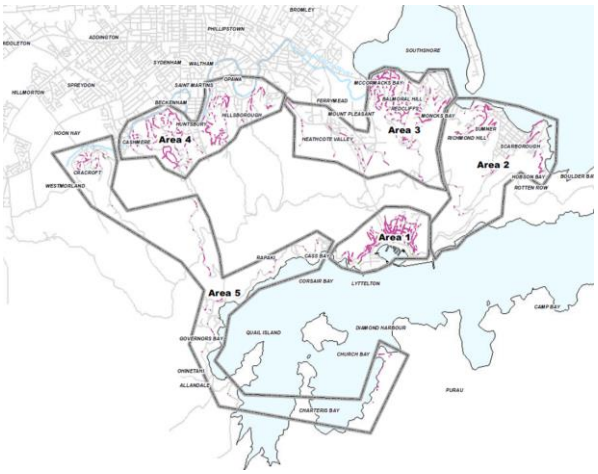

Figure 6, The five geographical areas for the retaining wall rebuild programme.

The determination of the geographical areas was predominately set around each area having similar rebuild values.

The prioritisation score of the retaining walls was used to group the walls in each area into packages. If necessary, any major or emergency projects were removed from these packages and delivered under separate projects.

The five SCIRT Delivery Teams were assigned a single geographical area except for Lyttelton, where the volume of repair requires two Delivery Teams to meet the required timeframes. This enabled the Delivery Teams to gain experience within a given area and achieve economies of scale, utilise plant effectively and reduce costs associated with mobilisation. This delivery plan also gave ownership to the Delivery Teams ensuring consistency in communication for interaction with the affected communities.

The allocation of geographical areas to design teams also had the benefit of consistent design standards and monitoring the overall condition of the area to refine the prioritisation process, manage risk and support the community.

Monitoring
The prioritisation process of the retaining walls was monitored in conjunction with the SCIRT clients by regular reviews of the MCA criteria, relative weightings and the overall

ranking. Any changes in emphasis or the introduction of new or different criteria were applied globally to preserve the integrity of the process.

Conclusion

The following key conclusions have been reached:

- Determine the number of Council and, within reason, private retaining walls.
- Be clear on who is responsibility for maintaining the asset.
- Obtain good and complete asset data.
- Have a consistent approach to wall attributes and condition ratings.
- Consider using an asset management software programme e.g. RAMM.
- Capture and manage data early, as opposed to during the challenging times of a post disaster event.
- Establish a transparent, robust and consistent prioritisation process for maintaining the walls.

The Council is currently building on the work developed by SCIRT to manage the retaining wall network long term. RAMM is to be developed to incorporate not only the wall physical attributes but to include a risk score. The risk score is the product of the likelihood and consequence of failure, following a similar philosophy to the prioritisation scoring system described in this paper. The condition rating of the wall will be based on the NZTA system. The assessment criteria will be developed to minimise subjective inputs and utilise drop down lists and example reports. The work will provide clear direction for managing the retaining wall assets. The outcomes will include risk profiling which will assist in short, medium and long term planning of maintenance activities and annual budgets.

The application of the lessons learnt from the CES can provide road controlling authorities and councils with confidence in managing their retaining wall assets. The principles however of fully understanding your assets are far more reaching and are applicable to all businesses managing assets worldwide.

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References

Christchurch City Council, (2013). Determining responsibility for retaining walls. Transport and Greenspace Unit. City Environment.

Stone, E., Gibson, M. F. L., Wilkins, P. R., and Newby, G. (2015). Seismic performance of retaining walls on the Christchurch Port Hills during the 2010/2011 Canterbury Earthquakes submitted to ANZ2015.

Author Biography

Philip Wilkins, MIPENZ, CPEng, IntPE
Beca Ltd., PO Box 13960, Christchurch 8141, New Zealand
Phil.Wilkins@beca.com

Philip is a chartered engineer with over 10 years' experience in structural engineering working on a broad range of civil infrastructure projects developing key asset assessment, design and project management skills. Phil was the Structural Asset Assessment Coordinator for the Christchurch infrastructure rebuild and responsible for the assessment of and prioritisation of the retaining walls.