16th World Conference on Earthquake, 16WCEE 2017

Santiago Chile, January 9th to 13th 2017

Paper N° 4672 (Abstract ID)

Registration Code: S-U1464730834

HORIZONTAL AFTERMATH: LESSONS LEARNED FROM INFRASTRUCTURE REPAIR IN CHRISTCHURCH, NEW ZEALAND

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Abstract

Horizontal infrastructure is often overlooked in an earthquake damaged city, because it is out of sight, therefore out of mind. This paper discusses aspects of the challenges in coordinating the repair and rebuild of earthquake damaged horizontal infrastructure within the Christchurch central city rebuild from 2011-present day. In Christchurch, New Zealand, there were no established ways to deal with the massive rebuild efforts required, particularly of the infrastructure. Systems and processes were developed and redeveloped several times post-earthquake. First hand examples from the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) alliance model and Canterbury Earthquake Recovery Authority (CERA), a government organization, are discussed to showcase how effectively the rebuild performed. Lessons learned will be discussed regarding data organization, quality assurance, future proofing and insurance, shared trench layout and Private Utility Company compliance with national laws. This paper is the opinion of an employee that was engaged at both the alliance and the government organization.

Keywords: infrastructure, Christchurch New Zealand earthquake, earthquake recovery model, lessons learned, opinion

1. Introduction

Christchurch's central city and eastern suburbs were badly affected, with damage to buildings and infrastructure already weakened by the magnitude 7.1 Canterbury earthquake of September 4, 2010 and its aftershocks. The shallowness of this earthquake caused major liquefaction and significant damage to the utilities. Further, on February 22, 2011 a magnitude 6.4 earthquake struck an area 2 km west of Lyttelton and 10 km southeast of the city center. The ground intensity and again, the shallowness, of this earthquake cause major damage to homes, infrastructure and lives. 185 people were killed in this major event. These two earthquakes and hundreds of aftershocks severely crippled the infrastructure and left the central government of Christchurch scrambling for a plan while also carrying out emergency repairs on the infrastructure.

Horizontal infrastructure is often overlooked in city, because it is out of sight, buried beneath the ground. Christchurch, New Zealand is no exception. The local government operates in a typical 'patch mode' style in which if something was broken, they would fix it, but only that section. Funding for resilient infrastructure was not available, or was available, with limited ineffective values. Enforcement of a holistic solution was not a power that the local government of Christchurch held or seemed to desire, making the infrastructure business driven by private companies. This description is considered a 'business as usual' scenario, pre-earthquake.

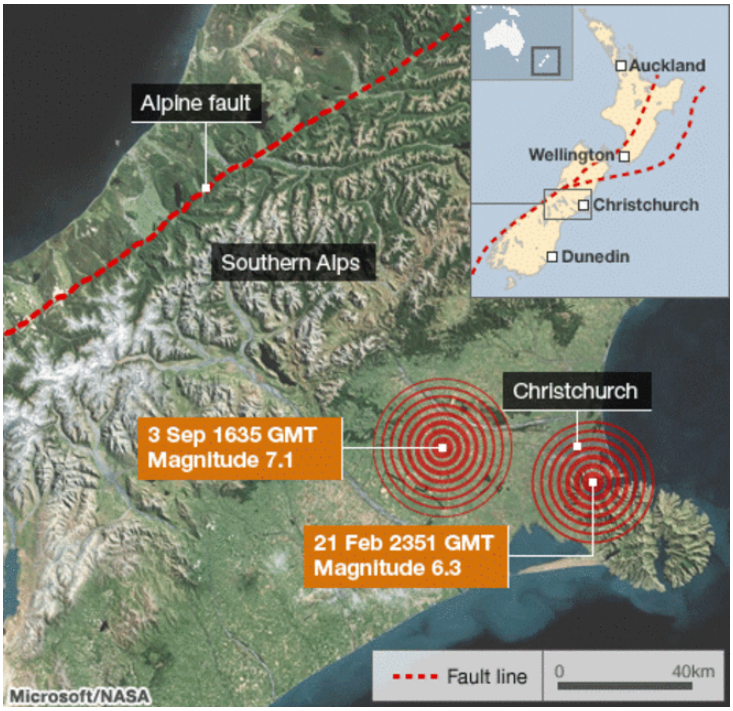

Figure 1: Location of Major Earthquakes in Christchurch

2. Earthquake Damaged Infrastructure Gets a Strategy

In September 2011, seven months after the last major quake, Christchurch local and New Zealand national government formed an alliance of local and national government agencies and construction contractors called Stronger Christchurch Infrastructure Rebuild Team (SCIRT). SCIRT is a team of public and private companies that agreed to work in a contract arrangement called an alliance.

An alliance is formed between public entity funders and asset owners, which are also referred to as "owner participants" or "clients", and private contractors, which are known as "non-owner participants". Each non-

owner participant provides a delivery team to carry out the physical construction works. The alliance arrangement is the delivery vehicle used to carry out a construction project or program of works. The SCIRT alliance involves three owner participants (the three public entities) – Christchurch City Council (CCC), New Zealand Transport Agency (NZTA), and Canterbury Earthquake Recovery Authority (CERA) – and five non-owner participants. The five non-owner participants are City Care Limited (City Care), Downer New Zealand Limited (Downer), Fletcher Construction Company Limited (Fletcher Construction), Fulton Hogan Limited (Fulton Hogan), and McConnell Dowell Constructors Limited (McConnell Dowell). Among the three public entities, CERA is a funder only, CCC is a funder and asset owner, and NZTA is a funder and asset owner. (Office of the Auditor General - New Zealand , 2013)

CERA was established as a government department on 29 March 2011. CERA was established under the Canterbury Earthquake Recovery Act 2011 to provide strategic leadership and to co-ordinate activities to ensure an effective, timely, and co-ordained rebuilding and recovery effort in Canterbury. CERA did not own any of the infrastructure asses, but was a significant funder of the repair.

CERA was disestablished on 18 April 2016 as the New Zealand Government transitions from leading the recovery, to establishing long-term, locally-led recovery and regeneration arrangements.

As you can tell from the following structure, Figures 2 and 3, the process for completing the repairs was quite extensive. With funding also coming from CCC and NZTA, multiple checks and balances have kept progress creeping along. The author of this paper was employed for two years at SCIRT as a project engineer and two years at CERA as an infrastructure coordinator, this allows for a more complete perspective on this discussion. The SCIRT alliance is still in operation today.

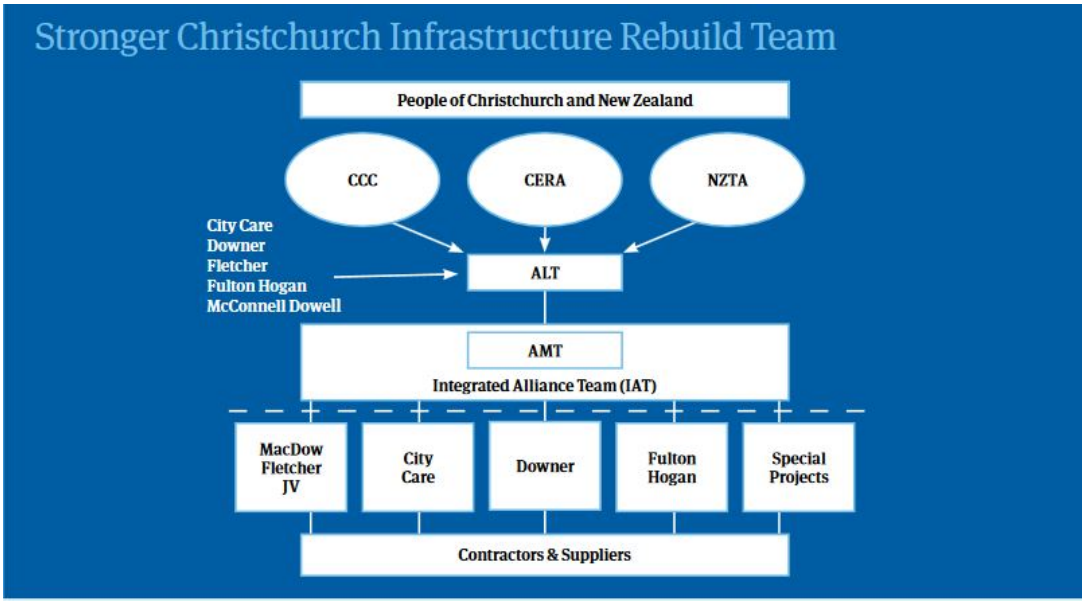

Figure 2: SCIRT Structure

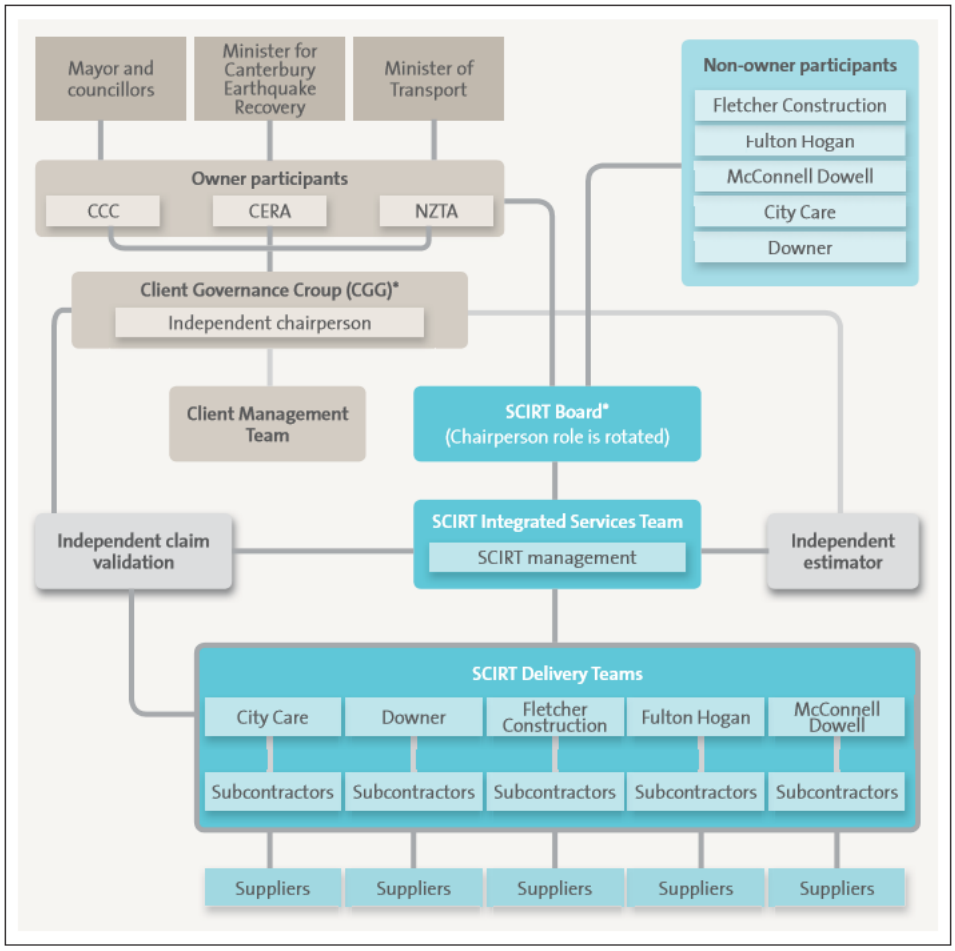

Figure 3: SCIRT structure with Governance entities

3. Summary of Earthquake Damage and Recovery

The initial estimated cost to repair Christchurch's damaged horizontal infrastructure was $2.015 billion (this figure includes SCIRT and non-SCIRT work). In 2013, a revised estimate for the SCIRT component of the work assessed the costs as $2.496 billion. It will be funded by CCC, NZTA, and CERA. In June 2013, the New Zealand Government agreed to contribute a maximum amount of $1.8 billion to the rebuild of horizontal infrastructure. (See Figures 4-6) The maximum amount includes funding 60% of costs for the water infrastructure, and NZTA funding 83% of the road infrastructure. CCC will fund a total of $1.14 billion. (Office of the Auditor General - New Zealand , 2013) Additionally, the damage to the electrical network (see Figures 4, 6 and 7) estimated that the permanent earthquake repairs took three years and cost $70 million overall to complete. Full restoration of the electrical network to previous levels of reliability is expected to take three (2014) to five (2016) years. (Kestrel Group, 2011)

As mentioned, the infrastructure damage was significant. Statistics of the earthquake damage and repair efforts are as follows as well as sample damage images.

	Damage (km)	Complete repair as of April 2016 (km)
Wastewater pipe	683	533

	Damage (km)	Complete repair as of April 2016 (km)
Stormwater pipe	78	56
Freshwater pipe	96	91
Roads (in area of m^2)	1,667,754	1,384,236
Electricity cables (66kv)	50% loss (30 km)	90%
Electricity cables (11kV)	15% damage (330 km)	95%
Electricity cables (LV)	1% damage	100%
Electricity substations	4 out of 314	50%
Fibre optic – various reporting	20% loss	10%
Tram tracks	80% loss	60%

Figure 4: Damage and Repair of Infrastructure data appears courtesy of SCIRT and Orion LTD

Figure 5: Sample photos of earthquake damage photos appear courtesy of SCIRT

Figure 6: Typical underground utilities

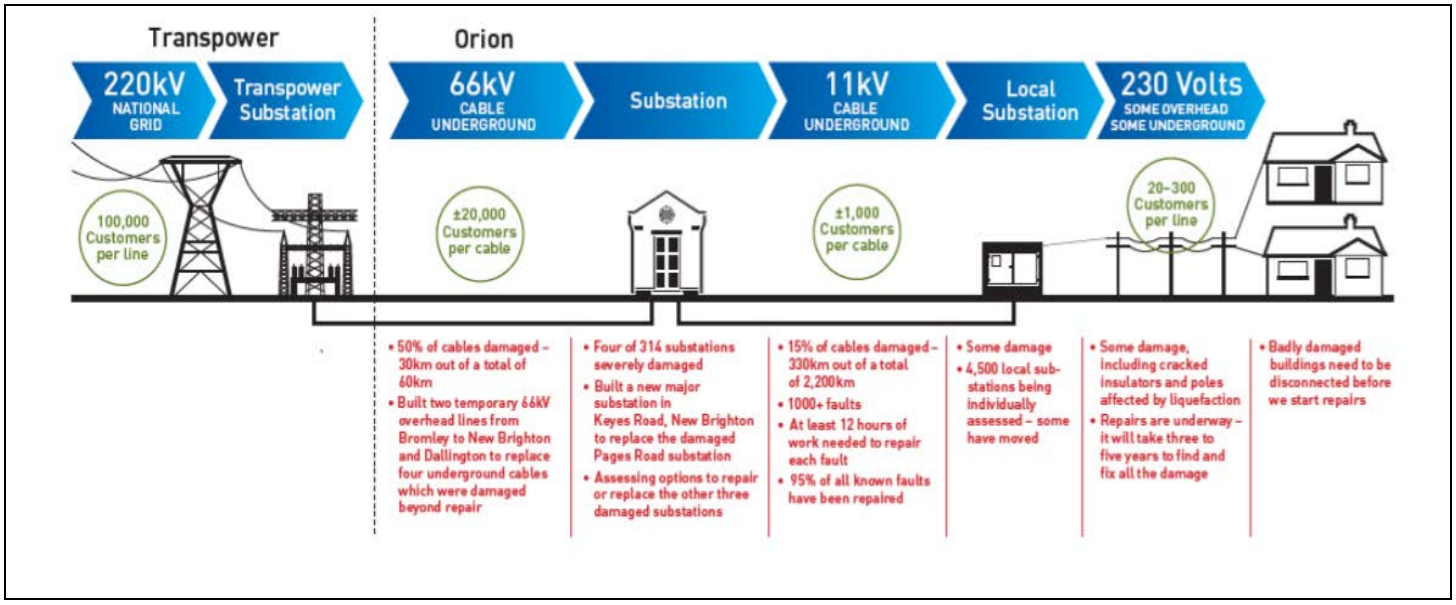

Figure 7: Overview of Damage to Orion Electricity Network, February 2011 (Watson &Massie, 2011)

The earthquake did significantly disrupt the infrastructure in Christchurch; however, the asset management systems in place with CCC and other utility companies pre-quake were not in an adequate position to deal with such a disaster. There were boxes of records, closed circuit sewer videos (CCTV) footage, piles of location maps, and mountains of other data just lying around collecting dust. With the earthquakes brought a higher need for coordination amongst utility providers, some of this communication did not come about with favorable outcomes given no apparent 'fair' payment method to private utility companies given the government directed rebuilding. Daily meetings would occur with SCIRT and CERA and utility companies, attempting to achieve the best result for the rebuild. As you can see the plan to repair the infrastructure and the progress to complete the repairs has been lengthy. The political and insurance situations have not helped the timeframe with money and decision making either. The rebuilding is still ongoing, and will likely be for several more years. Following are opinions of lessons learned in important topics relating to utilities and rebuilding infrastructure.

4. Lessons Learned

4.1 Was an alliance model (SCIRT) an effective way to rebuild a city post disaster?

The SCIRT alliance model did afford for a city and its working professionals to become upskilled at a rapid rate. It takes a city to rebuild a city, so to speak. However, the anti-competitive nature of the alliance model does have its downfalls. It is often commented that without the competitive nature of business the timeframes and budgets get blown out of the water. Also it did take seven months to even set up the alliance, post disaster. It has been interesting to be from a country that has high regard for time and deadlines and work in a country that has a far more relaxed attitude. From a non-nationals perspective, a lot of time and money could have been saved by creating a healthy competitive environment among the consultants and contractors within the city of Christchurch.

The SCIRT model should have afforded Christchurch City Council (CCC) the luxury to redesign their city how they wanted, as a local government. However, it was often viewed that the employees of CCC wanted to wait and see how the national government would handle the payment before proceeding. Coincidently, given the complicated nature of the alliance, many of the infrastructure decisions and designs were changed several times prior to construction. On account of these attitudes, many opportunities were not realized and rebuilt infrastructure was often not future proofed for the next disaster.

4.2 The need for data organization

Every city should strive for some kind of complete asset management system, including a schedule for repair and replacement of old assets. CCC has both, but not in any sort of organizational matter in the presence of an earthquake. As previously mentioned, most of the CCTV footage that existed pre-earthquake was stored in a warehouse, in boxes, with no organization. This scenario made it difficult/impossible to compare the existing infrastructure condition with the pre-existing condition. A significant number of assets needed to be reassessed given no relation to the post-earthquake condition. This made the insurance payments quite difficult, as there was no prior proof of correct maintenance. There was also no formal CCTV analysis system set up in CCC to ascertain when a pipe should be replaced, what factors and with what degree of damage contributed to its replacement. The alliance model did assist CCC in getting a system in place to analyze CCTV and create a rating system for the repair or replacement of assets. In this case it was better for the skilled professionals within the pipe condition assessment field to be within the same alliance, working together. The asset management component of SCIRT is ongoing, as there is now much work to get the new data developed at the alliance site back into ‘business as usual’ within the CCC building.

4.3 Quality Assurance Process – Engineering Representative

There was no/extremely limited engineering oversight (from the alliance) of the construction process after the alliance spent several months designing and engaging contractors in meeting regarding the design. This misstep caused several instances of incorrect construction. This rework was not completed at the contractors’ cost, in most cases. A lesson going forward would be to have engineer present during the construction to add to the quality of the repair. The alliance had a motto that suggested everyone to be ‘generous with trust’, which was very idealistic in this scenario. The culture of the alliance was generous and hardworking, however most construction projects in the world have an engineer’s representative overseeing the construction of the design.

4.4 Futureproofing and insurance for assets

Unfortunately, due to the limited funding from a combination of available funds and insurance monies, there was limited capacity to future proof assets for the next earthquake scenario. Representatives from the alliance would suggest, in sound engineering judgement, that infrastructure assets should be upgraded to create a safer and more resilient network. Often times this would not be achievable due to the lack of funding from the government

(CERA), the city (CCC) or insurance payouts. A lesson learned from this topic would be to assure that assets are adequately insured and that the plans for the city account for growth in regions and also natural disasters.

4.5 Uniform utilities layout – shared trench

Opening a trench to install new or repair old pipe is an opportunity. The design team has an opportunity to take a glimpse of the underground network and improve all expose utilities. One opportunity that is presented is the concept to place pipework, fiber optic and electricity cables in one trench. This model is arduous to organize and legally time consuming. However, to me, the benefits far outweigh the negatives due to the fact that all utilities are installed within the same trench and in an organized manner. Typically, there is no cost savings in this model, given the extensive collaboration necessary with all utility providers; however, the road network does benefit from limited traffic disruption by using a single point of entry to install all underground utilities in one trench.

4.6 Private Utility Company compliance with national laws and rules set forth, including local government enforcement

This topic is fascinating to me because it requires entities to work together. As such, it was extremely difficult to coordinate this effort in the rebuilding environment of Christchurch. One of the national codes of utilities in New Zealand requires that; "… corridor mangers are required to coordinate the work of the various utilities within their districts, including their own, in a way which ensures the best outcomes for all New Zealanders in terms of the performance and longevity of the utility services and the transport corridor." The issue with this Code is that it requires entities to agree on a cost agreement, alignment and other design elements. Where this concept falls down is that, in the rebuilding of the earthquake, CERA was unwilling to pay for the extra design and coordination this Code required. CCC was also unwilling to pay. When there is a requirement for collaboration and no one is willing to pay for extra collaboration and design, the Code falls by the wayside. In theory, this Code should be enforced by the national government, requiring all parties to participate. In practice, this Code was never enforced. A lesson learned here would be to ensure that the local and national government is willing and able to empower employees to enforce Code's that will positively impact the rebuilding efforts.

5. Conclusion

Given the ideal scenario of affording enough time to properly prepare for an earthquake, it is the opinion of the author that an alliance is not the most efficient way to proceed in a post-earthquake scenario. Taking the competitive nature out of a business scenario is not advantageous to the clients. Parties involved in the alliance model were not the most skilled consultants and representatives for the job.

As an alternative arrangement to an alliance, the local municipal government should take a more active role and the engineers that work at the municipal level should be leading the repair efforts. Leading from the municipal level, not the private sector level, would encourage better project cohesion and consistency. The municipal employees will know their systems and plans the best of any company that could be working on the repairs. The municipal leaders could then 'award' new infrastructure work to the private companies that are preforming the best, thus creating a more competitive market for the continued repair work. This format requires very strong leadership and cooperation from the municipal level.

The aftermath of this earthquake can teach municipalities that they need to prepare for a worst case scenario situation and keep records and employees updated at all times. It is highly important to employ highly skilled people to enforce and carry out what is best for the municipality and its residents.

An earthquake is a terribly humbling experience, but repairing the infrastructure after the event does not have to be a complete mess with large over expenditures. It is important to have a plan, and employ the best people to implement this plan.

The rebuilding of Christchurch, New Zealand's infrastructure will take many years to stabilize. Many lessons were learned of the local and national government as well as the engineers and contractors employed for the project. Politics and money aside, the project did afford a great deal of knowledge to the inhabitants of Christchurch during this time.

References

Kestrel Group. (2011). *Resilience Lessons: Orion's 2010 and 2011 Earthquake Experience.* Wellington, New Zealand: Kestrel Group Ltd.

Massie, Watson. (December 2011). IMPACT OF THE CHRISTCHURCH EARTHQUAKES ON THE ELECTRICAL POWER SYSTEM INFRASTRUCTURE. *BULLETIN OF THE NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING*, pages. 425-430.

Office of the Auditor General - New Zealand . (2013). *Effectiveness and efficiency of arranagments to road repairs and roads in Christchurch.* Wellington, New Zealand.