# CentrePort Wellington: Resilient regeneration activity

*P. Terry; A. Delaney*
CentrePort, Wellington.

*W. Juno*
Holmes, Wellington.

*C. Keepa*
WSP, Wellington.

## ABSTRACT

Wellington's Pipitea port precinct - a critical lifeline and economic contributor to Wellington and surrounding regions – suffered significant damage and associated operational disruption as a result of the 2016 Kaikōura earthquake. Resilience is a central theme to response and regeneration, and a core objective to achieving a long-term sustainable business through incremental improvements.

The immediate emergency response and recovery after the earthquake is shared herein so that our experience can be leveraged for the benefit of the wider community. The earthquake presented the port with a wide range of hazards and competing interests. To confront these safely required fast and accurate communication, a 'safety first' culture, application of sound judgement, consistent processes and high trust within a network of contributors.

In the medium term, the port and its partners invested in a range of hard and soft measures to ensure the ongoing safe connectivity of the wider port network. A specific focus for infrastructure was interim improvement / securing to address latent risks. In conjunction, demolition enhanced longer term safety and resilience for the port through flexibility of use.

In the longer term, the port team is embracing regeneration through four key equal regeneration pillars (Our People, Our Customer, Our Environment and Our Community) with enhanced understanding of its criticality and its importance in how it operates across these four pillars. CentrePort have established their own recycling facility for reuse of demolition material in our resilience programme – reducing environmental impact whilst enhancing viability through reduced long term costs, all the while contributing to resilience of the port. There is considerable effort

being put into ground resilience and an increased sense of importance across the four pillars of regeneration.

## 1 INTRODUCTION

Wellington and the lower North Island of New Zealand rely upon CentrePort's marine assets, relationships and operations for connectivity. CentrePort provides infrastructure, handling, transfer and support services in support of a wide range of transport logistics, tourism, freight, and goods movement.

See Figure 1 for CentrePort's different Wellington sites. The Pipitea precinct is in central Wellington. It is used for import, export, transfer and storage of logs, containers, horticultural products, cement, new and used vehicles, petroleum and more. This central hub is also the site for two interisland ferry operators, tug and pilot boats and Wellington's cruise ship terminal. Fuel transfer facilities operate at Miramar (Wellington) and Seaview (Lower Hutt). Inland freight hubs are in operation at numerous lower North Island locations, servicing the regional transfer of goods from road to rail transport. This eases the burden of heavy goods vehicles on SH1 and SH2.

### 1.1 Context

Since the port is an essential part of the national fuel supply chain, rail and state highway network, it serves a lifeline function under New Zealand's Civil Defence and Emergency Management Act[1]. Given many of the other services noted above, it is also a critical economic contributor to Wellington and surrounding regions.

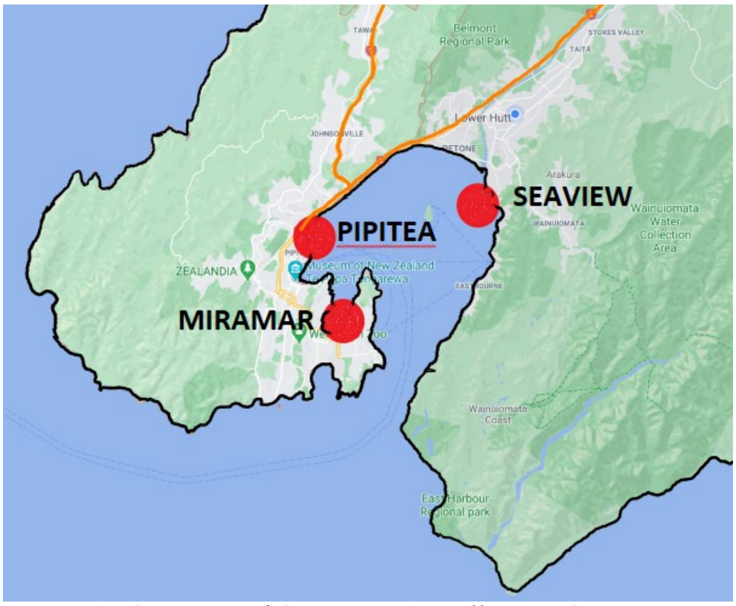

*Figure 1: Overview of CentrePort's Wellington Sites*

The Kaikōura earthquake has been well-documented amongst the local engineering community. It occurred just after midnight on 14 November 2016. It was a magnitude 7.8 event on the Richter scale. It severely damaged property and infrastructure throughout central New Zealand, including at CentrePort's sites. As a consequence, there was significant operational disruption and response activity. This was followed by a series of short, medium and longer term regeneration activities. This paper discusses these, along a theme of resilience – the ability to adapt and thrive in the face of the unexpected – which underscores the past four years of activity.

## 2 IMMEDIATE RECOVERY

### 2.1 Damage triage process

The first step to a resilient response was a triage process to understand the relative impacts of the earthquake across the port in a coarse sense. This appraisal of severity, underpinned by a clear understanding that safety came first, would provide the basis for making robust decisions.

Engineering review teams were arranged by skill set to suit the needs of the shift, and nobody worked alone for safety reasons. The initial response was driven by a wide range of contributors, and the ability to draw on a history of knowledge around the site was critical to fast decision-making. Typically, prior knowledge was contributed by staff from CentrePort, Holmes and Tonkin and Taylor. Many key people had worked together on 2013 earthquake responses and/or technical assessments of expected performance of structures on port. These senior engineers led the inspection work with a focus on known prone areas based on their prior work. Appropriate judgement accompanied engineering observations such as shown in Figure 2. Similarly, operations crews appraised damage to accessways, power systems and subsurface utilities. These initial technical and non-technical triage conclusions were reported back at wider team meetings three times a day.

*Figure 2: Some triage-stage observations: settlement, impact of buried structures, unstable containers, tilted light poles, exposed services, structural damage, operations on hold, ships at anchor.*

A workshop building, centrally-sited on the port, was used as a hub for the response team. This had been identified after Seddon and Grassmere earthquakes in 2013 as a sensible site based on operational need and observed structural response of various different CentrePort buildings.

Team briefings were held three times daily, so that all involved in triage were regularly updated and refreshed. The team was briefed for their next objective based on a priority list. Priority was determined based on safety, lifeline connectivity and thereafter a range of practical and economic factors. A wall-sized map of the port was central to this discussion, with a traffic light system of annotations. All port areas started with a red annotation on the map. As triage progressed, zones or structures were classified with one of three colours based on the hazards and damage observed. Some remained red and inaccessible where deemed unsafe. Others were reclassified as intermediate or low risk as confidence built on the safety to use an area.

*Figure 3: A triage-stage briefing session*

Communications staff were liaising with CentrePort employees not able to be on site. Links were also drawn to the engineering community via "clearing house" meetings, contributing to industry awareness of the level of impact that the earthquake was to have on the region. Operating in a vacuum can exacerbate stress and lead to spread of disinformation. This was mitigated through plenty of talking, simple messages, clarity of common purpose and priority, despite – or perhaps because of – the shared discomfort of the situation.

### 2.2 Damage triage conclusions

One impactful outcome of triage was the pace with which certain structures and zones were classified as – or adapted to be (refer Figure 4) – fit for some level of access and use. While many older port structures were not "resilient" by current theoretical measures, the people and processes informing response offered resilience to the wider system. As an example, despite damage, no fuel transfer operations were delayed and interisland ferries were operable within 24 hours. Within 48 hours, logs and other bulk trades were resumed, and shortly after that the port served as a loading site for navy ships delivering aid to Kaikōura.

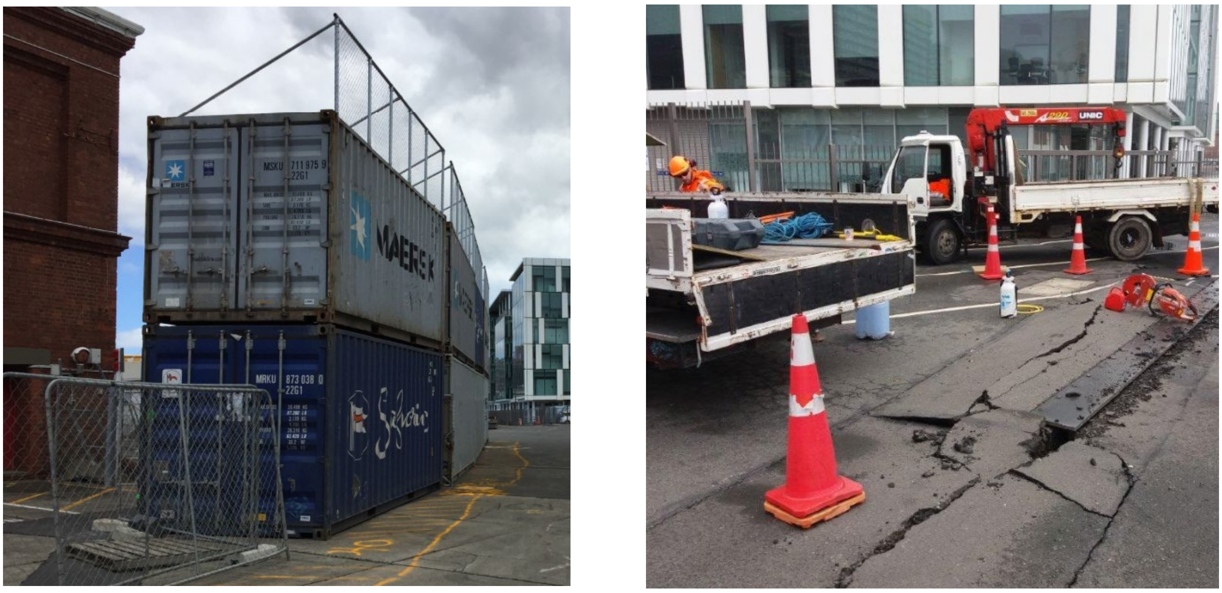


*Figure 4: Interim measures to reinstate safe access around the port*

A key element in getting to this outcome was clarity in communication. The focus at this point was to record status using simple, clear tools ("traffic light" system, large maps, standard Rapid Assessment forms), and to share information in person regularly. Another key to achieving this outcome was resilience in knowledge base. Many within the triage team had years of collegial experience in Wellington's port environment. A deep understanding was thus available to contextualise the impact of observations such as cracks and deformation. Trust already existed between many of the key people on site. This contributed to freedom of challenge and support around key decisions, and a level of care which ensured safety remained front of mind.

## 3 SHORT TERM REGENERATION

By mid-December 2016, the triage exercise had brought a reasonable level of clarity of what the port had experienced. Most damage had resulted from differential displacement and/or ground deformation. From this point, a more structured approach was taken to planning response activity on a one to five-day horizon.

Exploration of different technologies (drones, 3D image capture, software systems, analysis methods) proved useful for data capture at this time. There was a sharpening of people's focus toward three main areas:

- observation, measurement and appraisal
- interim repair or securing
- port operations

Ongoing damage inspections continued, securing work was underway, and the whole port was operating to some degree. While infrastructure resilience is likely well known to the technical reader, this operational success is derived from the presence of business resilience as outlined in the following examples.

Port staff proved their adaptability. Many took up new roles in the face of a changed operating environment. Some learned new skills and swapped teams. Others helped to change processes – for example the port safety induction process was personalised due to the influx of regeneration contributors. In this respect, a process change was implemented to ensure clarity and consistency for people, since the operational environment was necessarily evolving. This set of adaptions was possible through commitment to training and development, and a strong culture shared across an operational business at all levels.

On 23 December 2016, cruise ship Ovation of the Seas berthed at Aotea Quay under known limitations to become the largest cruise vessel ever accommodated in Wellington – a fantastic outcome for the city. This was achieved because the port's asset management procedures offered process resilience. The engineering and marine teams drew on recent inspection and rating data for bollards, plus existing technical mooring models from key suppliers in order to manage the mooring of the ship around damaged infrastructure.

CentrePort drew on the strength of existing customer relationships so that geared container ships could be brought to Wellington from early 2017. This re-established container movement for the region despite the ship-to-shore cranes being non-operational.

This stage was one to ensure sustainability in the regeneration process. It was important for the port and its people to consolidate new operational processes and embed safe ways of working within a damage-affected site. It was a chance for those heavily embedded in response work to manage stress levels and plan for regular, rather than urgent patterns of work. Back up options were established, both hard like road access, and soft such as communication lines. This was a key enabler for ongoing progress in tough conditions.

# 4 MEDIUM TERM REGENERATION

## 4.1 General

During 2017, there was further definition of key activities, so the port and its partners could fully focus on particular tasks. Numerous teams progressed elements of physical works planning and delivery. In parallel, many individuals stayed focussed on inspection, assessment and reporting as part of the insurance resolution process. While not discussed in detail here, this was an essential aspect of the long-term resilience of not just the port as a business, but the city and region. The process enabled CentrePort to secure an appropriate settlement against damage which heavily impacted commercial resilience. It also enhanced the team's understanding of how performance of built infrastructure affected transport logistics for the region.

## 4.2 Wharf securing

In many cases, assessment of wharf damage indicated that the risk of controlled use of damaged structures was tolerable. For Thorndon Container Wharf (TCW) and Kings Wharf, however, this was not the case. These wharves were subjects of securing projects to mitigate risk of interim use to an acceptable level.

TCW securing has been documented for this audience previously (Presland et al[2]; Palmer et al[3]). Kings Wharf securing followed a similar philosophy; design and construction of adequately robust structures in the reclamation to which the wharf could be secured. As for operations at TCW, this increased levels of certainty of ferry operations by building back an appropriate level of performance in moderate seismic events.

Lateral spread of the reclamation adjacent to Kings Wharf had pushed the wharf deck seaward by over a metre in the worst locations, as shown in Figure 5. Safe operation of vehicle traffic on both deformed ground and the wharf was limited with cordons. Wharf piles in the areas of largest deformation were likely fractured at depth, and the primary vertical and lateral load paths heavily compromised. This presented a hazard to marine operations: aftershocks could trigger progressive collapse, creating an obstruction in the berth pocket.

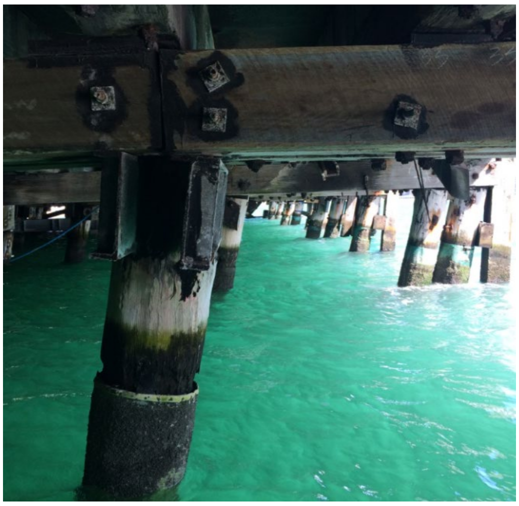
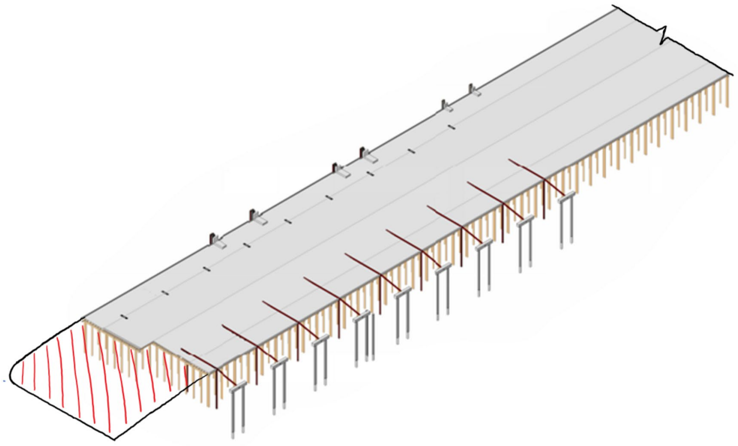

*Figure 5 - Deformed piles from seaward displacement of wharf deck (L); Overview of securing work (R)*

The portion of most heavily deformed wharf was demolished. Bollards were relocated to create an adapted interim mooring arrangement. Stone columns enhanced the reclamation adjacent to the wharf. A portion of wharf manageable (though large) deformations was secured back to the improved ground. This was achieved by bolting steel tie beams to the wharf deck and anchoring them into the concrete pilecap of an in-ground piled frame. These measures, illustrated in Figure 5, mitigated the worst risks of further seaward movement.

The load path for fender loads was reinstated, since ground movement had compromised the ability of the wharf deck to bear against in-ground thrust blocks. Thrust blocks were rebuilt, and a range of other minor modifications were completed to address lost access and high-risk areas of localised damage.

### 4.3 Demolition

A tranche of demolition work was established in 2017. This saw the removal of severely damaged buildings where required for safety reasons, or where demolition (and potential replacement) was economically preferable over repair. Some in-use buildings were demolished where their function was otherwise able to be met to enable commencement of the long term Regeneration. Others contained hazardous materials such as asbestos, or were disruptive to operations – i.e. original wharfside structures now landlocked by 20$^{th}$ century reclamation work. The disruption caused by the earthquake represented an opportunity to safely remove these buildings, and also to level off uneven ground and contain pockets of contaminated land.

Over a dozen buildings were demolished, plus some historic buried structures, thus relieving port staff of exposure to numerous current and future hazards. CentrePort are left with more flexibility, now, to plan the future port and regeneration activity, since numerous spatial and safety constraints have been removed.

### 4.4 Medium-term infrastructure solutions

Further infrastructure adaptions were implemented in this period, too, so that the port and its people could keep working in a safe and healthy manner. Damaged cladding panels were secured for the safety of building users and passers-by. Seawalls were repaired, and rail and pavements were reconstructed to support safe transportation. The floor of Straddle House was replaced in response to earthquake-induced settlement and floor damage. Clearly these safety matters were wide-reaching, and repair work affected hundreds of people

Further, since CentrePort House – a hub for those on port – was heavily damaged, a portacom village was planned and constructed to accommodate CentrePort staff. The village was built incrementally, to house an ever-changing group of teams as the regeneration process developed. The portacoms were light and shallow-founded, meaning that they could move with the ground in the case of further deformation.

A huge amount was achieved by those working on services – 3 waters, electrical and communications in particular. Damage was present in almost all cases where buried services entered into a piled building, since the piled structures hardly settled but the ground containing the services moved hundreds of millimetres.

### 4.5 Ground improvement

Once the importance of ground deformation was established, CentrePort undertook to make the site more resilient for future use. The Kaikōura earthquake demonstrated how the ground conditions and the Thorndon Basin affect the ground shaking experienced at the site in earthquakes. Liquefaction-induced spreading of the revetment slopes, lateral stretch and settlement of the backlands were significant contributors to the damage of structures, utilities and pavements and the disruption of operations following the earthquake.

A detailed understanding of the seismic hazards at the port has been integral to understanding the risk that the port is exposed to from earthquakes and for port regeneration planning. Extensive ground investigations, laboratory testing and assessment have been carried out in collaboration with the University of Canterbury, NIWA and GNS to characterise the ground conditions across the site and develop a detailed understanding of the seismic hazards at the port. This work has shown that the ground shaking and liquefaction hazards are different to previous estimates and that contrary to previous thoughts, the gravel reclamation fill at the site is liquefiable. To assess the liquefaction resistance of the gravels, state of the art cyclic simple shear testing was carried out on large reconstituted gravel samples at the University of Michigan.

To improve port resilience to earthquakes, the focus has been on constraining lateral movement of the liquefiable gravelly reclamation fill. A 12 m to 40 m wide strip of stone column ground treatment around the perimeter performs this role. Stone column ground improvement has proven to be effective at increasing the liquefaction resistance of the gravel fill and provides some flexibility for future development. Noise and vibration during construction can be limited to acceptable levels. The use of crushed recycled concrete from demolished port structures has reduced the cost and environmental impact of the ground improvement work.

## 5 LONG TERM REGENERATION

In the longer term, the port team is embracing regeneration with enhanced understanding of its critical risks and how it operates. By considering four equal key pillars (Our People, Our Customer, Our Environment and Our Community) and treating the port as a holistic system, resilience improvement options have been identified, and business justification aligned to the four key pillars. Some of these are discussed below.

CentrePort and its partners have enhanced their understanding of which assets are most critical to port operations, and how built resilience can be implemented to best effect. Where feasible, the port layout has been adjusted to reduce exposure of critical assets to seismic hazards and improve operational redundancy. This includes removal of redundant structures, upgrade of critical services, consolidation of operational functions and creation of flexibility (i.e. transport routes). Performance requirements for new infrastructure and upgrade schemes have been developed considering the criticality of the asset and the desired overall resilience and risk profile of the operations it supports.

There is considerable effort, with core partners, being put into understanding and improving the resilience of the ground, particularly where historic reclamations have performed poorly in the past. This, in addition to work described above, serves as a means of self-insurance against disruption and safety impacts under future settlement-inducing earthquake events.

CentrePort has incrementally changed its container-handling strategy, to move away from tall straddle carriers. These vehicles were particularly prone to safety issues when exposed to uneven ground conditions, due to their high centre of gravity. This move has provided opportunity to embrace the future, and Gaussin are suppling a fleet of fully electric tractors to support container logistics on port.

CentrePort established their own recycling facility in 2017. This facilitated reuse of demolition material not just around the port, but across the region on other projects, too. This reduces environmental impact of the earthquake damage whilst enhancing the viability of regeneration projects through reduced long term costs. All the while, this contributes to the long-term sustainability and resilience of the port; broadening business activity and knowledge base and making use of land previously left for storage.

The earthquake recovery process presented the port team with a chance to shift their mindset in terms of asset management. A transition is underway to a new data storage platform. This offers better access for both port staff and external partners to a single, central source of truth. Initial use has shown added value in use and maintenance of bollards, light poles and other assets. Further progress is planned over the coming years.

A final success story was the relocation of all port staff into a regenerated Shed 39 in late 2020. This has created an increased sense of community and connectivity with all port staff sharing not just a common workspace, but a base that all feel an ownership over.

## 6 CONCLUSIONS

While regeneration remains underway as a long-term activity, there are many lessons to be drawn from the experience of CentrePort and its partners since the 2016 Kaikōura earthquake.

CentrePort's success in rapid recovery of operability was influenced by resilience in their relationships. The short-term response saw fast action and accurate communication among key internal and external contributors with capability and relevant prior knowledge. Investment and reinvestment in mutually valuable relationships is one way that a business can set itself up well to address the unexpected.

In the medium-term response to an event, business resilience has a big part to play as people adapt and try to sustain momentum under new operating procedures. Organisational investment in staff development and culture is important. It leads to flexibility of people's application and a common positive intent to continue to progress in the face of adversity. Clarity in processes minimises risk of misuse, and strong commercial leadership is necessary – whether in negotiating a path through an insurance claim process or otherwise.

CentrePort have invested in resilience improvements, with a focus on the four key pillars of Regeneration. This ensures that infrastructure investment is focused on addressing the right risks on the right assets to ensure a sustainable and resilient business. Demolishing buildings, for example, can provide redundancy to reduce risk around traffic flows while removing latent risks or hazards. Ultimately, CentrePort's current and future resilience in the face of the unexpected is borne out of an understanding of how their port operates and interfaces within the ecosystem of the four key pillars of Regeneration– through both hard and soft measures.

## 7 REFERENCES

1. Civil Defence Emergency Management Act (2002); https://www.legislation.govt.nz/act/public/2002/0033/48.0/DLM149789.htmlDisaster
2. Presland, R.A., Chin, E.L., Boyce, A., Delaney, A., Lake, J (2018, April 13-15). *Thorndon Container Wharf Securing Works – An overview.* NZSEE Conference, Auckland, New Zealand.
3. Palmer, S., Chin, E.L., Presland, R.A., Chalmers, G., Delaney, A, Lake, J (2018, April 13-15). *Thorndon Container Wharf Post Kaikoura earthquake securing works; Seismic risk evaluation and response to that risk.* NZSEE Conference, Auckland, New Zealand.