AFTER THE 2011 QUAKE: REBUILDING CHRISTCHURCH'S POLYETHYLENE PIPE NETWORK

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ABSTRACT

In February 2011, a 6.2 magnitude earthquake caused devastation to buildings, roading and infrastructure in Christchurch, New Zealand. Christchurch is New Zealand's 2nd largest city with a population of 400,000. During the quake over 6,500 people were injured and 185 people lost their lives.

Following the earthquake, Christchurch City Council (CCC) was faced with a major rebuild of the city's drinking water, waste water, stormwater and gas pipeline network. The city's existing Polyethylene (PE) watermain pipeline network performed well during the quake and CCC chose PE as the material of choice for all new water and wastewater pressure pipelines.

PE was first used as a pipe material in the 1960's by British Gas who replaced steel pipelines with PE pipelines. Despite half a century of use as a piping material, a knowledge deficiency persists in the installation of plastic welded joints.

During 2012, local and international construction workers poured into Christchurch, seeking employment in the repair and re-build of the city's underground pipe network. Due to concerns around PE pipe installer skills, CCC implemented a destructive testing program of installed welds. The testing showed installation errors were leading to failures of newly installed PE pipeline joints and in excess of 30% of newly welded joints failed integrity tests.

CCC implemented an oversite system to monitor and improve welding performance. Within 12 months, less than 1% of electrofusion and butt welding destructive tests resulted in failure.

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1.0 INTRODUCTION

Polyethylene has a range of attributes including ductility, flexibility and non-corrosiveness and is increasingly selected as the material of choice for pipeline applications ranging from municipal water and waste water networks to irrigation, mining, gas and plumbing.

Polyethylene pipes performed exceptionally well in the Christchurch earthquake with only a handful of documented mains failures in the water and sewer networks.

Therefore CCC specified:

"All water supply reticulation pipework shall be PE until further notice, including laterals such as fire services and this applies to all areas across the city "

PE is mainly joined by one of 2 methods, butt welding or electrofusion. An underestimation of the knowledge and skill required for the successful installation of electrofusion joints persists in the installation industry and as the use of PE increases, shortfalls in installation skills have lead to concerns around pipeline integrity.

Some asset owner concerns regarding the quality of installation have resulted in attempts to 'design out' welded joints from projects. However, welded connections provide a monolithic system while other joining methods are mechanical in nature and as pipe sizes increase this creates risk in a piping system.

Instead of moving to different joining methods, a better approach is to improve the oversight of electrofusion installations by asset owners and the skill of installers.

This paper discusses how Christchurch City Council demonstrated that a well managed process which combines installation training with oversite can mitigate installation risks and deliver a long lasting, leak proof and robust pipeline system.

Christchurch Wastewater Treatment Plant. Courtesy Fusion Solutions.

2.0 INSTALLATION CHALLENGES

To test the long term integrity of electrofusion joints, 'pre-construction' sample joints are often welded prior to installers embarking on projects. The welded joint is sent to a testing laboratory where segments are cut from the circumference of the assembly and destructively tested using tensile testing equipment. The fracture surfaces of the weld interface must meet the level of ductile separation stipulated by AS/NZS 4129.

Some installers in Christchurch were found to be welding electrofusion assemblies which would fail the pre-construction laboratory weld tests. Because the test results were sent directly from the test laboratory to the installer, the installer would continue to carry out test welds until they received a 'pass'. This test result was then sent to the council who were unaware of previous results. The council then gave the installer the green light to commence the project.

Within a short period of time, the council found a significant number of newly installed joints were leaking. This prompted the council to carry out 'post construction' tests - newly installed joints were randomly selected by council staff, cut from pipelines and destructively tested. The results showed over 30% of the newly installed joints failed the requirements of AS/NZS 4129.

Christchurch Wastewater Treatment Plant. Courtesy Fusion Solutions

3.0 COUNCIL OVERSIGHT

In response, CCC tightened installer oversight and the destructive testing regime.

- Installers had to provide certification showing they had completed PMBWELD302E, an Australian certificate provided on completion of a formal electrofusion training course run by Registered Training Organisations (RTO's).
- Installers were required to follow the steps listed in Plastic Industry Pipe Association (PIPA) Guideline POP001 *Electrofusion Jointing of Plastic Pipes and Fittings for Pressure Applications.*
- Individual *installers*, not companies, were listed in an approved welder register administered by the CCC.
- New installers had to provide the CCC with 8 successful test weld results, paid for by the installer as part of their request for admission to the register.
- To prevent installers only choosing pass weld results for submission to CCC, laboratory test results were sent directly to CCC, not to the installer.
- All test welds were carried out at the installer's expense and factored into the project price.
- CCC created and administered a master record which listed all welders and test weld outcomes.
- It became apparent that greater skill was needed when working on larger diameter pipe. New installers were limited to DN250 for a period of 6 months while being monitored by CCC. Once CCC was satisfied the installer was competent, the installer could then undertake welds on larger diameter pipe. The installer had to supply 8 test weld results on the larger diameter pipe to be accepted onto that level of the register.
- To ensure welders were invested, all installation equipment had to be owned by the installer and suitable for the pipe size being worked on. Hire equipment was prohibited. Tooling was randomly checked by council staff.
- 1:20 'construction' welds were randomly selected by CCC for destructive testing. If a weld failed, CCC would test welds either side of the failed joint. If these failed all joints in the line were exhumed and replaced at the installers expense.
- Fittings and pipe were required to be supplied by approved manufacturers and conform to AS/NZS 4130 (pipe) and AS/NZS 4129 (fittings).
- CCC adhered closely to the regime, providing limited flexibility to installers who fell outside the requirements.

4.0 RESULTS

Immediately after the quake, CCC estimated over 200 individuals were carrying out electrofusion and butt welding work in Christchurch. The council's system forced installers to choose between developing skills and investing in equipment for certain pipe diameters or declining work. Installers also had to stand behind their workmanship – joint failures were replaced at the their expense.

The number of installers involved in electrofusion and butt welding fell as installers became specialized in either small or large diameter pipe. The distribution of work over a smaller installer base ensured installers businesses were profitable.

Within 12 months, less than 1% of electrofusion test welds resulted in failure and those that did, were almost always attributed to new welders, allowing quick and concise fault finding and remediation before delays or large costs were incurred.

Today there are 20 individual electrofusion and butt welding installers in Christchurch. Less than 0.3% of test welds result in failure.

The entire system was implemented and managed by a single staff member. The staff member had a trades background, however was not a engineer or plastics expert.

5.0 CONCLUSION

- Current welding installation processes frequently suffer from incorrect use or lack of necessary tooling.
- Asset owners should develop oversight systems for pipeline welders to follow.
- The cost of oversight is very low compared to the increased lifespan of the asset and potential cost of rework required.
- Oversight ensures key pipeline assets have long term integrity.

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