DON'T SHIFT BRICKS - A HERITAGE ASSET UPGRADE

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ABSTRACT

Ehara taku toa i te toa takitahi engari he toa takitini. | Success is not that of the individual, but that of the multitude.

How do you install structural liners in 4.3 km of fragile brick barrel pipes, when the existing access structures are too small to fit the lining equipment? Collaboration between contractors and designers provided a creative, off-the-shelf solution for a bespoke challenge. This ensured that new manholes could be installed without causing brick barrel collapse during construction, as well as directing traffic loading off the brick prior to the lining works occuring.

In 2019, Dunedin City Council engaged the Ō3 Collective (Isaac Construction, Jasmax, and AECOM) to design and construct an upgraded streetscape within the central 'retail quarter' of George Street and surrounding blocks. In addition to above-ground ammenity, the works include the renewal and upgrades of aged three waters infrastructure. Construction began late in 2021, and is anticipated to be finished in 2024.

Dunedin's central business district sits atop kilometers of egg-shaped, brick pipes conveying stormwater from the hillside to the ocean outfall. The brick barrels sit between 2 – 4 m depth to invert, and are either 900 mm high by 600 mm wide, or 1200 mm by 900 mm. These pipes were constructed in the 1870's and are therefore classified as heritage infrastructure. The most common defects pertain to the quality of lateral connections, however the residual mortar strength is variable after 150 years of service which has yielded locations with slipped bricks and similar localised defects.

Rehabilitation of the brick barrel stormwater mains was motivated by preserving heritage value, minimising environmental impact by reducing new materials and waste generated, and limiting construction / street closure timeframes. Cured in Place Pipe (CIPP) lining was the preferred rehabilitation method primarily due to its ability to conform to the egg-shaped host pipe.

To provide sufficient access for the the UV trains to cure the liner, the existing rectangular brick manholes were replaced with bespoke access structures. Collaborative design with the contractor yielded an ecconomically feasible, repeatable solution protecting and strengthening the heritage brick barrel. Previous similar works had used bespoke precast arches, however this design utilised a traditional off-the-shelf manhole riser in a creative application.

A cast-insitu foundation at the springline of the brick barrel was designed to act as two independent halves on either side of the main. This foundation meant excavation was minimised around the brick barrel, which mitigated the risk of collapse. A traditional, pre-cast manhole riser with a semi-circular cored opening could then be positioned over the brick to transfer traffic loading to the aforementioned foundation. The skilled construction team successfully installed these structures while preventing damage to the brick and facilitating quality lining of the mains.

KEYWORDS

Sustainability, science & engineering, brick barrel, CIPP lining, heritage

PRESENTER PROFILE

Eliza is a Water Engineer with design experience spanning upgrades and renewals across three waters infrastructure and treatment plants throughout project lifecycles. She has an additional role as an 'ESG Influencer' for AECOM where she embeds positive environmental and community outcomes through projects and business operations.

1 INTRODUCTION

Dunedin City Council engaged the Ō3 Collective (Isaac Construction, Jasmax, and AECOM) in 2019 to design and construct an upgraded streetscape within the central 'Retail Quarter' of the central business district (CBD). These upgrades included extensive three waters infrastructure works in conjunction with above-ground works. AECOM led the design works in an Early Contractor Involvement (ECI) model with Isaacs Construction and Jasmax to ultimately service the Dunedin City Council. Driven by constraints within the complex central city environment, extensive existing utility services and aged infrastructure, the project team developed innovative value engineering solutions through collaboration between the client, designers, and contractor. The Retail Quarter's three waters scope comprises:

- Upgrading 2.3 km of existing, 100-year-old potable water supply assets. Existing cast iron and asbestos cement was replaced with a rationalised design comprising DN180 - 250 PE mains. This renewal includes SMART meter installation and rigorous backflow prevention upgrades.

- 1.1 km of wastewater assets were assessed for replacement or rehabilitation via UV-CIPP lining, ranging in diameter from DN150 – DN675, laid at depths up to > 4 m to invert, with grades as steep as 19%. Infoworks modelling informed design accounting for increased population, liner thicknesses, and wider network improvements beyond the project extent.

- 884 m of circular stormwater mains ranging from DN150 – DN1350 were assessed and re-laid. A dedicated DN1350 main provides 'pressurised' service through the CBD to the ocean outfall. Infoworks investigation identified and re-sized limiting stormwater assets to resolve existing flooding issues. 'Non-traditional' streetscape drainage design included rain gardens and passively irrigated tree pits, stone v-channels, interpath drains, 'hidden' paver-infill sumps, as well as traditional sumps.

- 4.3 km of heritage, egg-shaped, brick barrel stormwater mains were rehabilitated with fully-structural, UV-cured CIPP lining. For lining train access, bespoke chambers were designed and installed on the fragile, unlined brick barrels.

This paper focuses on the design and installation of the access chambers to rehabilitate the egg-shaped, brick pipes conveying stormwater from the hillside, beneath the CBD, ultimately to the ocean outfall. These brick barrels sit between 2 – 4 m depth to invert, and are either 900 mm high by 600 mm wide, or 1200 mm by 900 mm. The brick barrels were constructed by hand in the 1870's and are therefore classified as heritage infrastructure.

The decision to line these brick barrels was motivated by preserving the heritage value of the assets, minimizing the environmental impact (i.e. waste generated and construction-phase emissions), and compressing the installation timeframe and therefore the impact of construction works on those inhabiting the CBD.

2 DISCUSSION

2.1 DESIGN DEVELOPMENT

Key issues to overcome to install the liners within the brick barrels were explored through the collaborative ECI model including:

- Existing manholes on the brick barrels were not large enough to fit the CIPP equipment.
- The existing access structures do not extend to pipe invert, rather they resemble chimneys extending to surface from the brick barrel obvert (refer Figure 1 and Photograph 1).

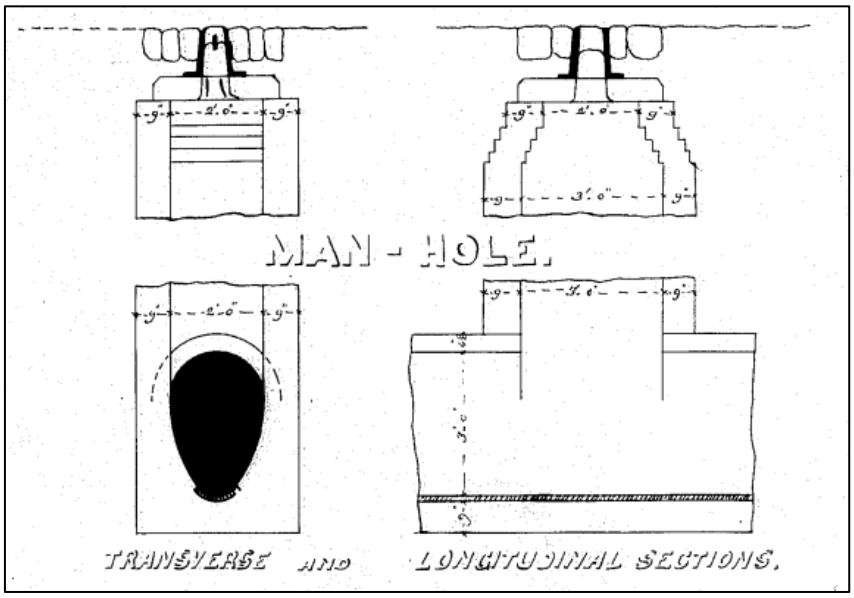


Figure 1: As-built of existing brick barrel access structure, 1870's

Photograph 1: Photos of exposed existing brick barrel access structures

- The structural integrity of brick barrel pipes is largely due to the compressive strength of the surrounding soil inwards, meaning that excavating around brick barrels is heavily reliant on the strength of the aged, frequently missing mortar.

- The process of compacting material surrounding a brick barrel poses risk of damage to the fragile structures.

- The new structures installed on the brick barrels prior to lining were required to take traffic loading prior to the lining works occurring due to project staging constraints.

- The compressed timeframe required for the physical works heavily favoured pre-cast components, preferably off-the-shelf.

Prior similar projects had used precast arches to marry the traditional manhole riser to the brick barrel. Refer to Figure 2 for concept sketches exploring potential interfaces between the existing brick barrel and the new manhole riser.

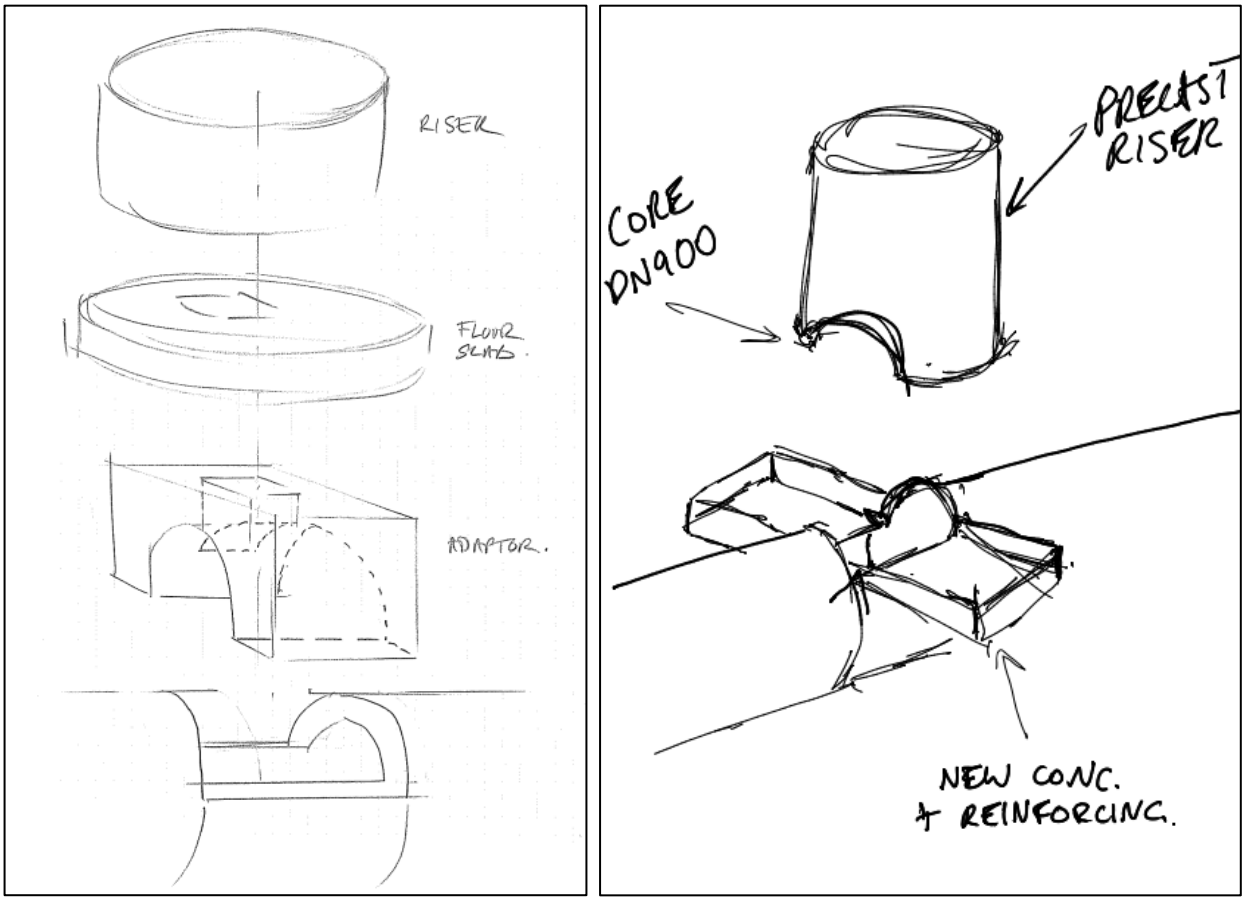


Figure 2: Concept sketches using a precast arch adaptor piece (left) versus a cast in-situ base with an amended riser (right)

Design decisions made collaboratively during the concept design phase included:

- The shape of the new structure (e.g. square versus circular).

- Installation methodology requirements to minimize construction-phase risk of brick barrel damage e.g. concrete pours extending to compensate for variable mortar strength to hold bricks together while exposed.

- Excavation extent for the new structures to the brick barrel spring-line versus to invert.

- Dimension of the structure footing (i.e. increasing horizontal footprint versus depth considering the large diameter of the new structures and the congested service corridor).

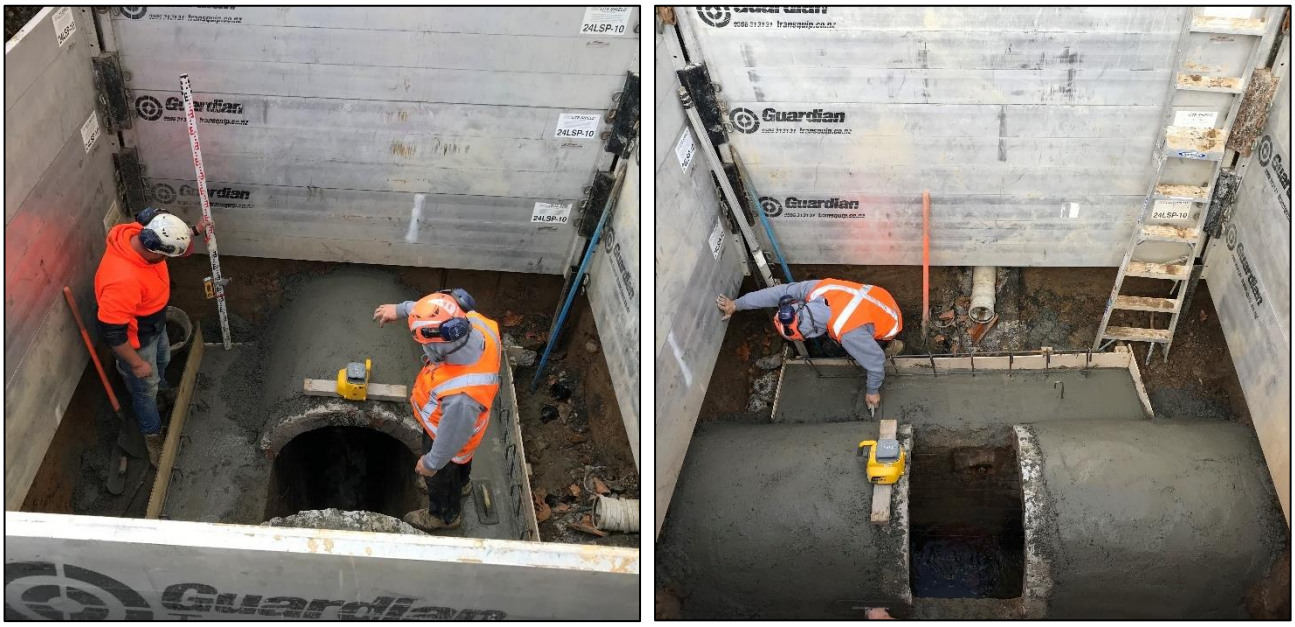
Ultimately through presentation and discussion of available options, a design was developed collaboratively. A cast-in-situ foundation at the springline of the brick barrel was designed to act as two independent halves on either side of the main. This foundation meant excavation was minimised below the widest point of the egg-shaped the brick barrel, which limited the risk of collapse. This facilitated a pre-cast manhole riser with a semi-circular cored opening to be positioned over the brick and transfer the bulk of traffic loading to the aforementioned foundation.

2.2 INSTALLATION

Isaac Construction's skilled team successfully installed the structures while preventing damage to the brick and facilitating quality lining of the mains.

Refer to Photographs 2 - 5 for images of the installation process.

Photograph 2: Preparing the brick surface after removing the existing access



Photograph 3: In-situ pour of new manhole foundation at brick barrel springline

Photograph 4: Installing new manhole riser with semi-circular core on brick barrel

Photograph 5: Installing benching and additional manhole risers

3 CONCLUSIONS

Heritage brick barrel pipes installed in Dunedin in the 1870's were rehabilitated via UV CIPP lining, requiring bespoke access to be installed on these aged assets. Collaboration between contractors and designers provided a creative, off-the-shelf solution for the bespoke challenge. This ensured that new manholes could be installed without causing brick barrel collapse during construction, as well as directing traffic loading off the brick prior to the lining works occuring.

ACKNOWLEDGEMENTS

Kia ora and many thanks to the Ō3 team and all the hard work that has been invested in getting the right infrastructure in the ground. Additional thanks to the DCC team for their vision and collaboration throughout the Retail Quarter project.