Shotcrete Solution To Tricky Underpinning Problem

by Roger W. Abbott

Figure 1: Initial condition of brick wall and block wall junction.

A downtown Vancouver excavation and shoring project involving underpinning of two adjacent structures took on a strange twist when it was discovered that the three-level, early 1920s building to the north of the excavation had a precariously attached brick wall founded on a rubble footing, which was required to be underpinned to construct the new building to the south. The structural engineer, acting for the owner of the existing building, determined that this brick wall was only tied in to the building at the roof and footing levels, with no intermediate support. Separation of up to 3/8 in. (10 mm) was already evident where the brick wall abutted a block wall in the lane (see Figure 1), and in this structural engineer's estimation, the wall could not withstand any further movement.

The geotechnical engineer's proposed underpinning design was a sequential

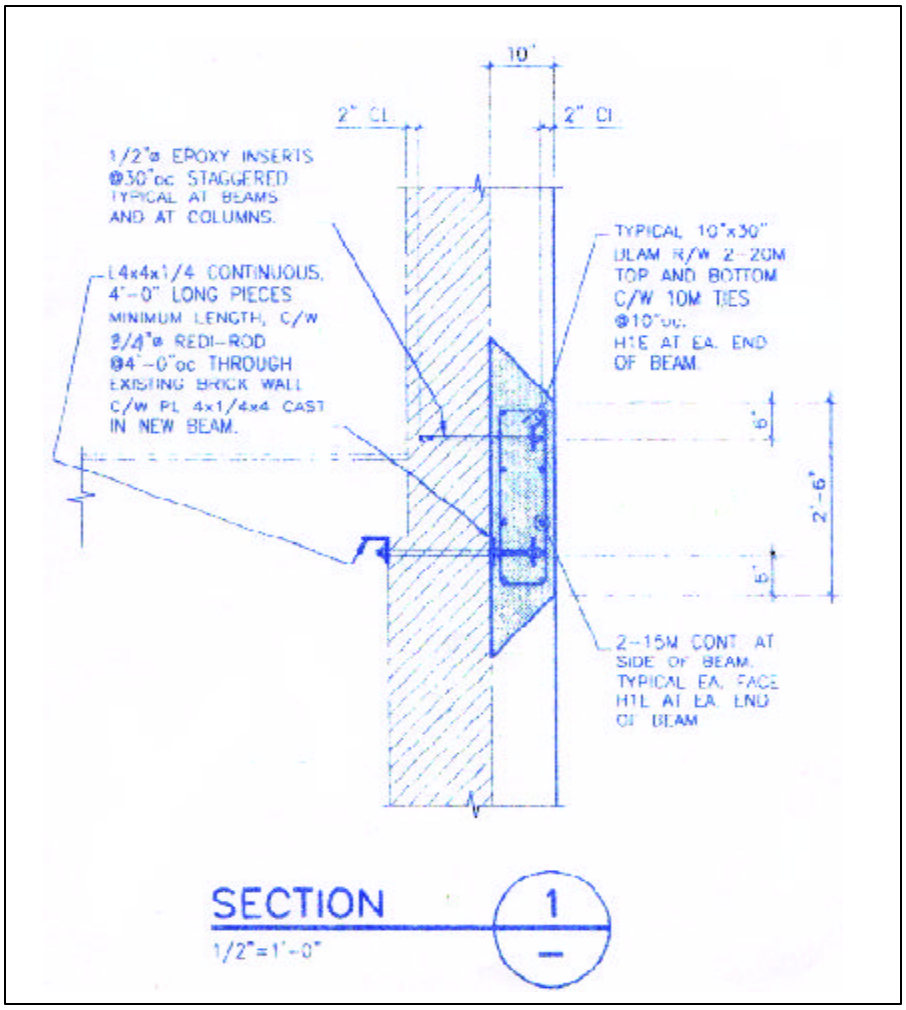

Figure 2: Details of bracing system. (1 in. = 25.4 mm)

Figure 3: Affixing angles and placing rebar for footing and first lift.

Figure 4: First lift in place and prepping for second lift.

shotcrete and soil anchor system to be constructed in panels. They had anticipated that up to 3/4 in. (19 mm) of horizontal and 1/2 in. (12 mm) vertical movement could occur. To further complicate the problem, it was found that the condition of the rubble stone footing on which the brick wall sat was unpredictable due to the deteriorated state of the bedding mortar, which was nonexistent in some areas. This type of footing was commonly used in early construction in Vancouver and had proven problematic at other locations. Unless this wall could be stabilized, the project could not go ahead.

The general contractor was now faced with the problem of how to proceed to safely stabilize this wall. The adjacent property was a fully operational Dollar Store and would not tolerate any interruption of business. Various options were investigated, including structural bracing, and even full replacement of the wall. The latter option would clearly involve closing the store and disrupting business for a lengthy period.

BelPacific, the shoring subcontractor, suggested an exterior bracing system utilizing a grid of reinforced shotcrete over the entire brick wall, with ties through to the floor joists at the four floor levels. If this could be progressively constructed from the footing up, the shotcrete structure would add flexural strength to the wall; and the wall would be tied to the existing floor joists.

This bracing system was reviewed by both the geotechnical and structural engineers and found acceptable -with some modifications for load transfer to the footing being made. Sizing and reinforcing details were provided by a specialized structural engineer, allowing the main design team to act independently from this unique solution. Cost estimates for the scheme were favorable, and construction proceeded.

The general contractor was able to perform the task of installing the joist tie-ins by accessing the ends of the joist through the T-bar ceiling after store hours. The 4 x 4 x 1/4 in. (100 x 100 x 6 mm) angles were attached to the existing joists, as illustrated in Figure 2, with redi-rod being drilled through the brick wall for fastening in the proposed shotcrete beam. This was done at 4 levels. Dowels were epoxied into the brick at 30 in. (760 mm) on center to hang the reinforcing.

The beams and pilasters were shot first to the underside of the first floor level to systematically build support from

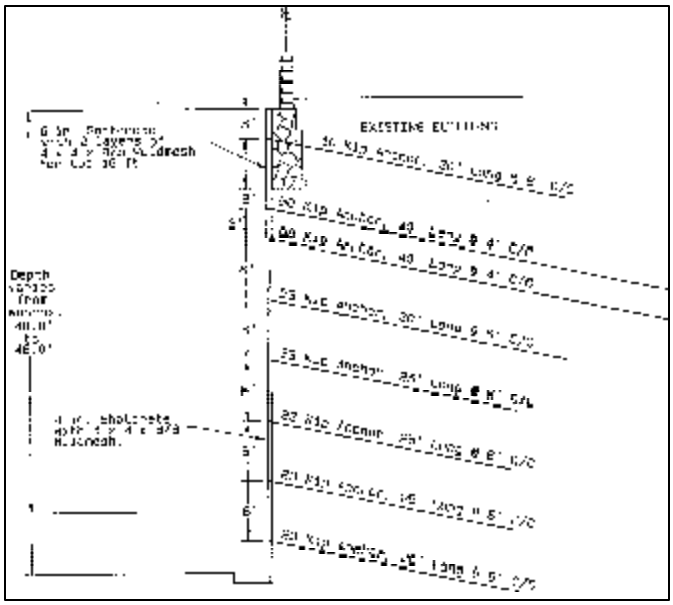

Figure 5: Underpinning section detail. (1 ft = 0.3 m)

the bottom up. The silica fume wet-mix shotcrete was cured utilizing a curing compound. The high early strengths attained enabled the next lift of rebar to be shot in 2 day cycles. This system progressively reinforced the structure as lifts were added. Typical 24-hour strength of the shotcrete was about 3050 psi (21 MPa), giving immediate rigidity to the structure. In this case, forming and pouring would have been a longer process. Superior adhesion of the pneumatically applied shotcrete over concrete was desirable.

A typical section of the underpinning detail is shown in Figure 5. The anchors were installed through stable beams, and the underpinning shotcrete was applied in a panel sequence by shooting a 5 ft by 5 ft (1.5 x 1.5 m) reinforced panel every fourth panel until the whole row was complete.

All existing walls were monitored regularly for movement. The shotcrete stabilized the rubble footing, tying the whole structure together.

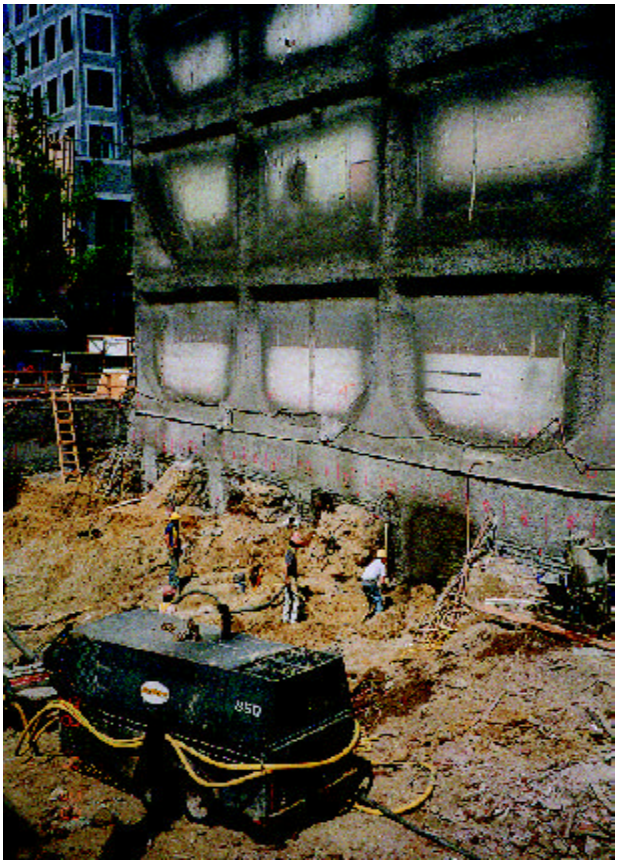

Figure 6: Panel sequence of underpinning.

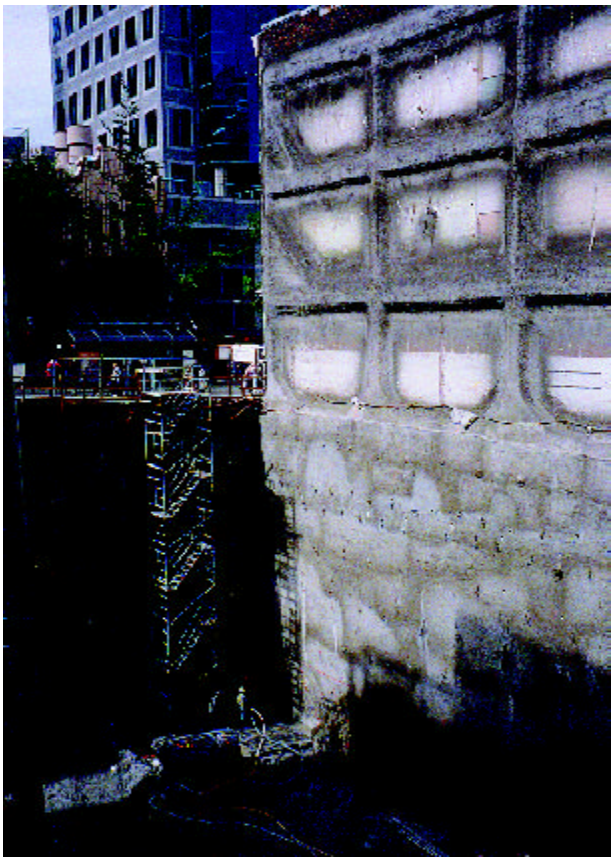

Figure 7: Completed underpinned and shored shotcrete.

The final structure is shown in Figure 7, 45 ft (14 m) below street grade. The shotcrete solution was a very quick and innovative approach to solving the problem, and it illustrates the adaptability the shotcrete method can provide.

Acknowledgment

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Geotechnical Engineers:	Cook Pickering & Doyle
Structural Engineers:	Read Jones Christofferson
Bracing Engineer:	Bogdonov Pao Associates Ltd.
Shoring/Excavating:	BelPacific Limited Partnership

Roger W. Abbott is Vice President of Shoring & Special Projects of BelPacific Shoring & Foundations, and Versatile Pacific LLC, affiliated shoring and foundation companies, whose main business is soil nailing and shotcrete shoring systems. He has a Civil Engineering degree from (now) Paisley University in Scotland, and has 30 years involvement with the development of temporary and permanent shotcrete shoring systems in the Pacific Northwest.