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16. Abstract This provides specific design recommendations, design considerations, and construction techniques for the construction of lateral support systems and underpinning. The design considerations are presented for each technique or method (soldier piles, steel sheeting, diaphragm walls, internal bracing, tiebacks, underpinning, grouting, and freezing). The factors affecting the design or implementation of these schemes are discussed. Construction techniques are presented, and literature references are provided for those seeking even greater detail. An overview of the construction methods compares the applicability of the techniques and the construction costs of each. Other reports developed from the study are FHWA-RD-128, Volume I, Design and Construction; FHWA-RD-129, Volume II, Design Fundamentals; and FHWA-RD-131, Concepts for Improved Lateral Support Systems.					
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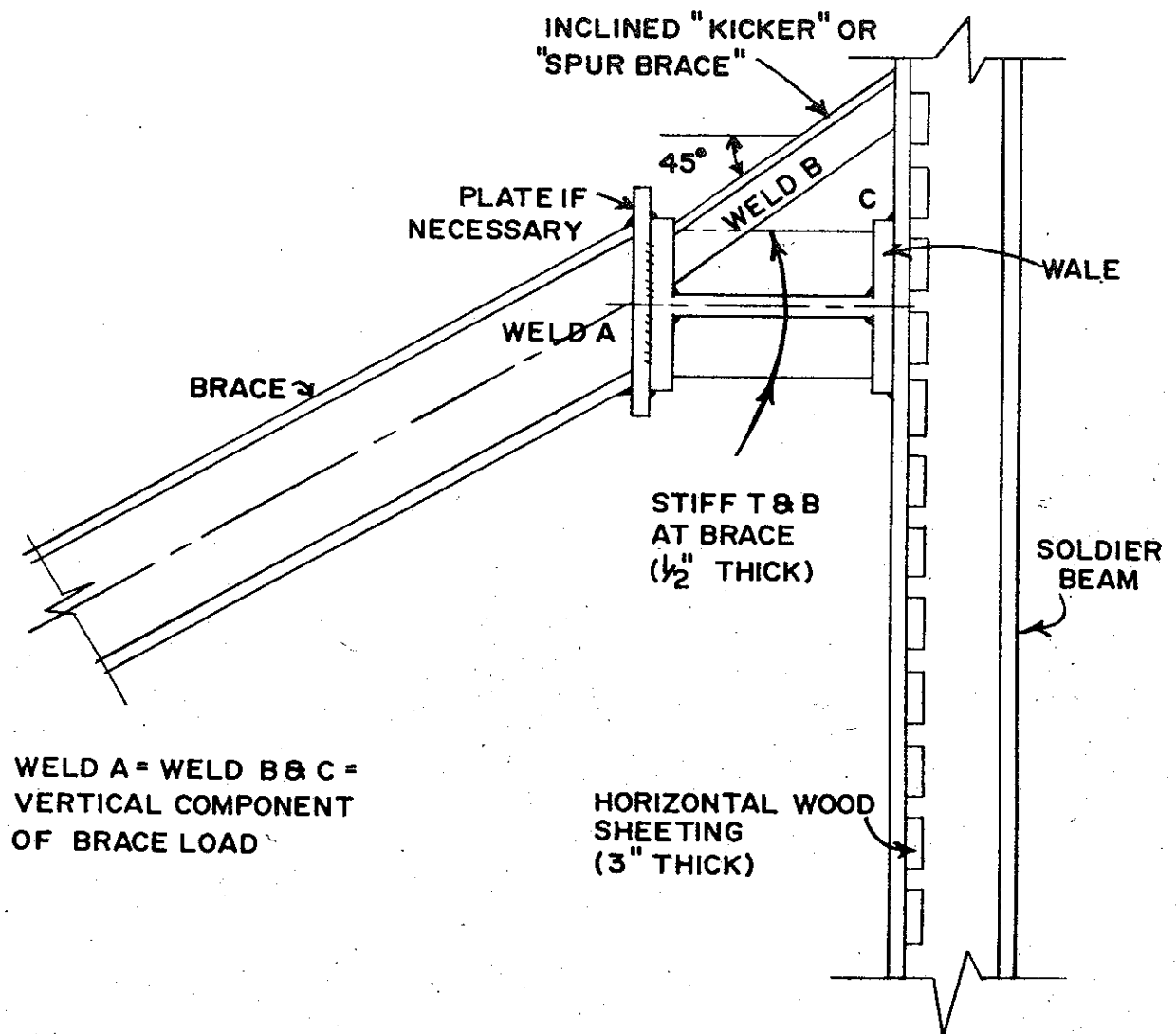


Figure 45. Typical connection for inclined brace and horizontal wale.

EARTH RETENTION SYSTEMS

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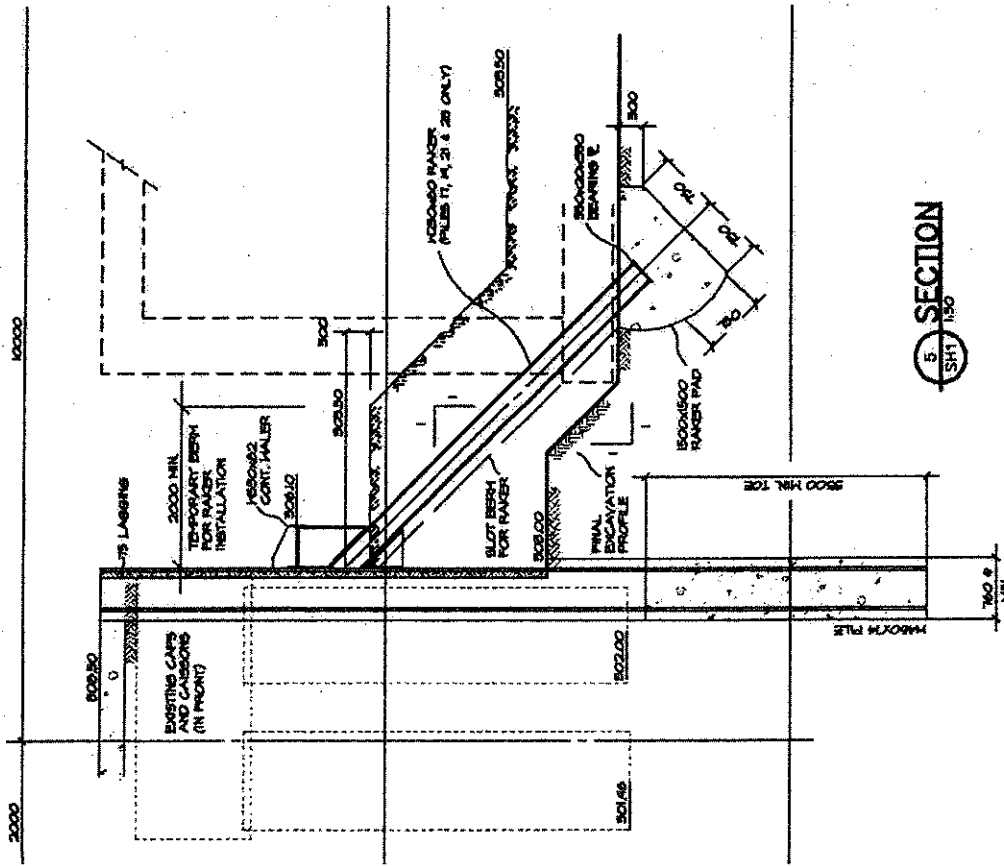
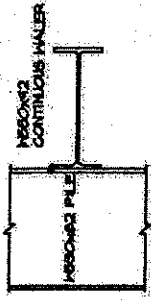


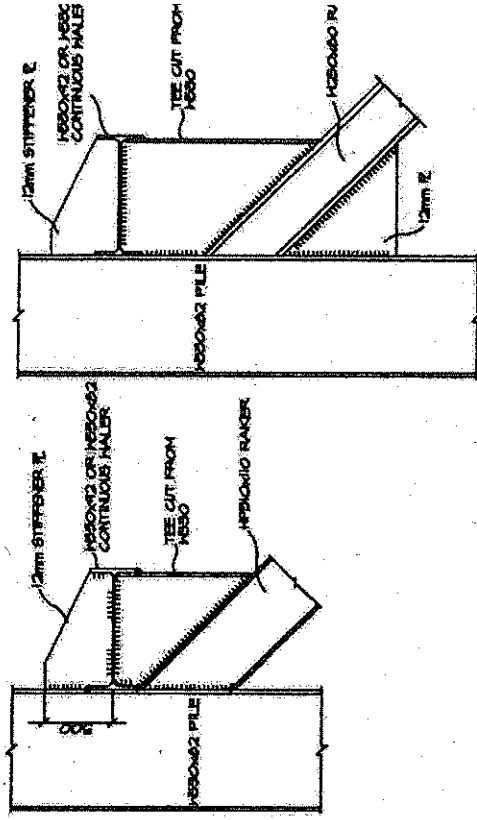
FIGURE 4.7 Typical raker section, Toronto, Ont. (Courtesy of Isherwood Associates, Oakville, Ont.)

Raker footings are usually unreinforced mass concrete which are narrow and deep. They can also be constructed as drilled shafts with a steel element cast in them to allow attachment of the raker. Figure 4.11 exhibits drilled raker footings. Preloading of rakers is often undertaken in order to restrict the movement of walls being braced by rakers. Large movements often occur to walls while the rakers are being installed, some of which can be recovered by jacking. The preloading of rakers is performed by jacking and welding which is labor intensive and adds significant cost to the shoring system. Once the raker is installed, and preloaded if specified, the berm can be removed.



NOTE: ALL WELDS SHOWN OR IMPLIED TO BE 3/8" MIN. FILLET WELDS UNLESS NOTED OTHERWISE.

PILE/WALER CONNECTION DETAIL



RAKER/PILE/WALER CONNECTION DETAILS

FIGURE 4.8 Typical raker direct connection to wall, Toronto, Ont. (Courtesy of Isherwood Associates, Oakville, Ont.)

Rakers must remain in place to provide lateral support to the wall until such time as the structure being constructed within the excavation can accept that load. Because of this, rakers must be left in place while construction progresses and structure must be built around the raker. This involves blocking out formwork to permit passage of the rakers through floors and walls. Once the structure is complete, the rakers are cut out, often in pieces, and the area left is patched.

4.1.1 Rakers and Walers

Because rakers interfere with formwork and can be difficult to excavate around, walers are often integrated with rakers in order to minimize the number of rakers installed. Walers (also called walers) are wide flange steel beams which are attached horizontally to the wall. The walers are designed as bending elements:

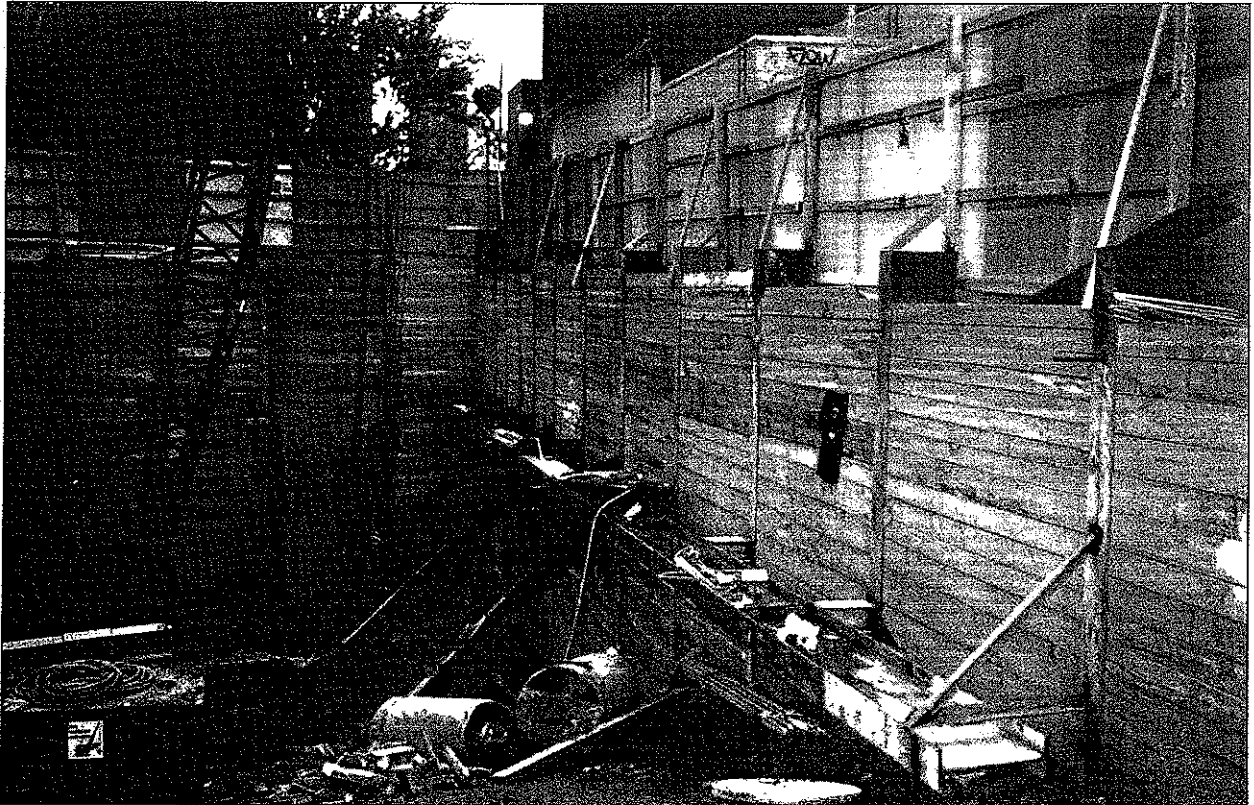


FIGURE 4.15 Waler to wall on stubs, Toronto, Ont. (Courtesy of Isherwood Associates, Oakville, Ont.)

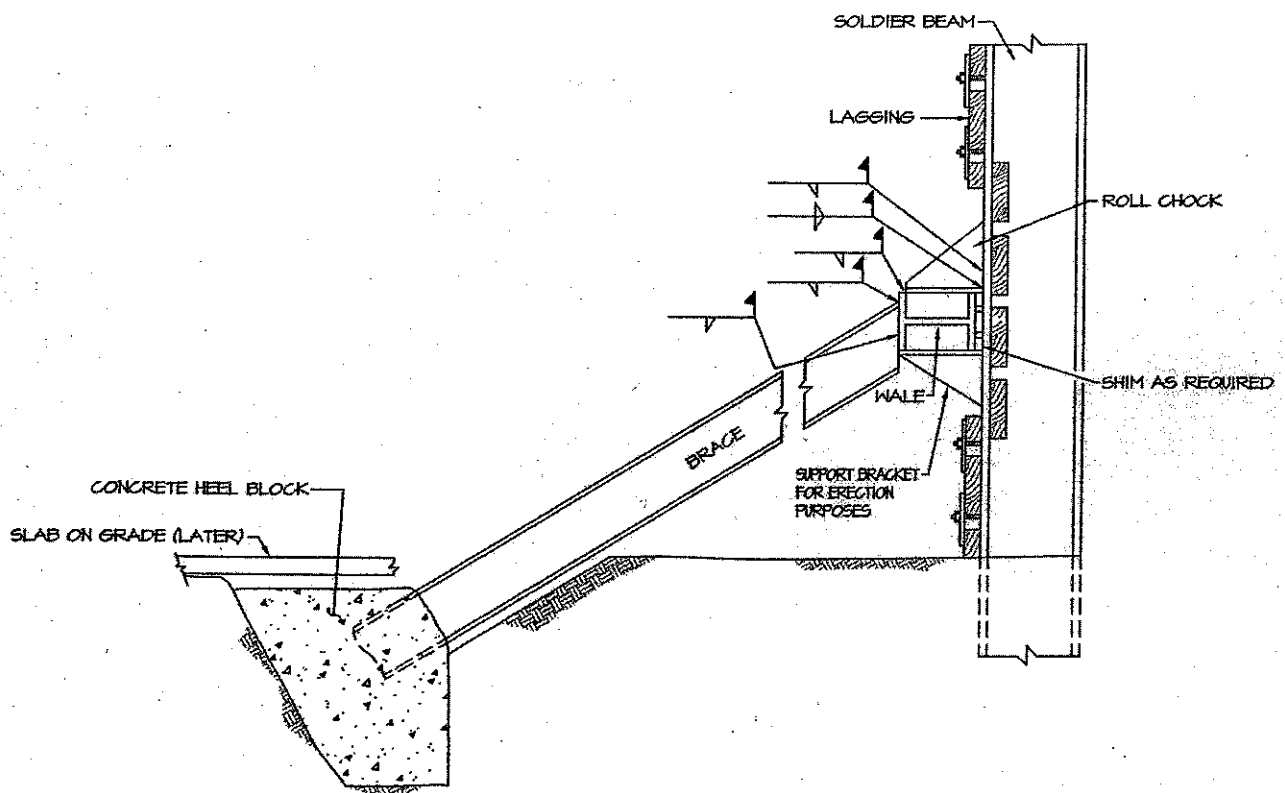


FIGURE 4.16 Typical connection of raker to waler. Note the use of a roll chock which prevents the waler from