dated for one year versus three months; the uplift soil resistance varied with the rate of uplift.

The timeframe for gain of backfill strength to achieve undisturbed soil conditions is difficult to determine. For application in soil-pipeline stress analysis, it is suggested that backfills older than 15 to 20 years may be assumed to have strengths and stiffnesses similar to undisturbed soil. This topic would benefit from additional research.

8.13   Effect of Backfill Strength on Horizontal Soil Stiffness

Figure 8.15 shows that for a backfill strength ratio (R_c) of 1.0, meaning the backfill soil strength is the same as the native soil strength, there is no effect from trench width on the horizontal soil resistance. This is to be expected. PRCI (2003) also presents data comparing the native undisturbed soil strength to backfill soil strength. Figure 8.20 shows the trends for various ratios of native to backfill strength, for one pipeline geometry. The general behaviour for other geometries is similar but is not scalable. For example, decreasing the H/D and W/D ratios tends to increase the normalized horizontal force. The general guidance from Figure 8.20 is that the horizontal soil resistance (force) is mostly independent of the normalized pipe displacement for a given ratio of backfill strength to undisturbed strength, but is very sensitive to the actual values of the backfill and undisturbed soil strengths.

Figure 8.20 also suggests some inferences for backfill aging. At initial backfilling, the ratio of undisturbed to backfill strengths may be quite high. With time, as the backfill settles and compacts, the strength will increase, and in the long-term the strength ratio will approach unity. With this increase in strength the horizontal soil resistance and associated stiffness would also be expected to increase.

8.14   Effect of Slope of the Trench Wall on Horizontal Soil Resistance

PRCI (2003) studied the effect of the slope of the trench wall on the lateral soil load acting on the pipeline. Figure 8.21 presents data showing the general trends in behaviour. As the inclination of the slope of the trench wall flattens, the horizontal displacement of the pipeline needed to engage the trench wall increases. At low displacements, up