the backfill soil temperature and the ambient ground temperature. It will therefore expand thermally towards the pipeline trench section that is not backfilled. The pipe is in a near stress-free, partially restrained state, during this expansion.

The net effect of this process is that during winter the pipeline temperature at full restraint may be on the order of -5°C or warmer. For the purpose of determining a design Delta-T value at restraint on backfilling, pipe steel temperatures colder than -5°C should be considered for only very cold air temperatures, especially when construction timing is protracted.

A similar, but opposite effect may occur in summer. The ground temperature at typical pipeline depths will be cooler than the air temperature in summer. As a result, the pipeline may contract thermally during the backfilling process, because the pipeline temperature during backfilling will be cooler than the ambient air temperature during summer.

8.16 Effects of Frozen Backfill

Chapter 6 showed that frozen soils have much higher short-term strength than the same soil in an unfrozen condition. However, there are several important considerations regarding the properties of frozen backfill. These include:

- Difficulty in placing frozen soils, and the delusion of compaction.
- Significant loss of strength on thawing of frozen backfill.
- Self-weight settlement of thawed backfill.

Successful and adequate compaction of frozen fill is rarely achieved. As a result, the compaction will be lower than if the soil was compacted unfrozen at its optimum water content. Reference to Figure 3.11 illustrates that compaction with zero water content will result in dry densities much lower than potential maximums. While the initial “subjective” field results of such compaction may suggest a high degree of compaction, this delusion is short-lived and spring thaw will inevitably prove the fallacy of frozen compaction. Figure 8.24 presents data on the effect of freezing temperatures on measured maximum dry density (when compared with the unfrozen maximum