JJ Mac Ltd

Technical Appendix:

Settlement Performance and Engineering Benefits of Cement-Stabilised Materials

A1. Purpose and Engineering Justification

This technical appendix presents a detailed justification for the use of cement-stabilised materials as engineered fill and foundation support. When designed and constructed in accordance with established standards, cement stabilisation provides a reliable solution characterised by low settlement, predictable mechanical performance, and long-term durability. The technique is especially valuable in situations where controlling settlement, improving construction efficiency, and ensuring long-term serviceability are essential design requirements.

The behaviour and performance of cement-stabilised materials align with the principles outlined in the Design Manual for Roads and Bridges (DMRB), specifically CC201 (formerly CD 225 and CD 226). These standards recognise hydraulically bound and stabilised materials as low-compressibility layers with negligible post-construction settlement, provided that adequate compaction and quality control measures are implemented.

A2. Material Characteristics and Design Intent

Cement-stabilised material is produced by uniformly mixing soil with a carefully controlled amount of cement, followed by compaction in layers to at least 95% of the Maximum Dry Density (MDD), as specified in BS 1377. This process transforms the naturally variable and moisture-sensitive soil into a bound composite material with substantially improved stiffness, strength, and dimensional stability. The primary design objective is to generate a structurally competent layer that can reliably support imposed loads with negligible deformation after construction.

A3. Settlement Behaviour and Performance Advantages

A3.1 Immediate Settlement

Due to the high stiffness of cement-stabilised materials, immediate elastic settlement under load is minimal and restricted to the period of construction or initial loading.

A3.2 Elimination of Consolidation Settlement

Cement stabilisation significantly reduces the void ratio and permeability of the treated soil, thereby eliminating the classical consolidation mechanisms found in untreated cohesive soils. Consequently, time-dependent settlement is not a critical factor in the design of such layers.

A3.3 Negligible Long-Term Deformation

The bound matrix of the stabilised material suppresses secondary compression and creep, ensuring excellent long-term dimensional stability even when subjected to sustained loading.

A4. Bounding Settlement Assessment

Empirical evidence and industry guidance indicate that the self-weight settlement of well-compacted cement-stabilised fills is typically less than 1% of the layer thickness, with the majority of settlement occurring during placement and compaction.

For example, if the stabilised layer thickness (t) ranges from 0.3 to 0.6 m and the residual post-construction strain is less than or equal to 1%, then the maximum settlement (s) can be calculated as follows:

- Maximum settlement, $s \leq 0.01 \times t$

Worked example: For a layer thickness of $t = 0.5$ m, the maximum settlement is $s \leq 0.005$ m (5 mm). This settlement takes place during construction. Post-construction settlement under service loading is considered negligible, thus supporting robust serviceability performance.

A5. Strength, Stiffness, and Load Distribution

The development of strength in cement-stabilised materials is typically confirmed through 7-day and 28-day soaked California Bearing Ratio (CBR) testing, which demonstrates both early-age and long-term performance. Indicative correlations suggest that CBR values in excess of 30–60% correspond to elastic moduli in the range of 50–150 MPa. This level of stiffness offers several benefits:

- Reduced stress concentrations
- Improved distribution of loads
- Lower risk of differential settlement

These attributes make cement-stabilised materials highly suitable for use in foundations, pavements, and areas subject to traffic.

A6. Durability and Environmental Resistance

When properly designed and compacted, cement-stabilised materials exhibit the following properties:

- Low permeability and resistance to moisture ingress
- High resistance to freeze–thaw cycles
- Minimal susceptibility to hydro-compression
- Stable performance under seasonal environmental variations

These characteristics contribute to a long design life and minimal maintenance requirements.

A7. Construction Efficiency and Quality Assurance

In addition to their performance advantages, cement stabilisation provides notable construction benefits, including rapid strength gain that allows early trafficking, reduced need for excavation and imported materials, and consistent, testable quality through routine site verification. Quality assurance procedures generally include in-situ density testing, moisture control, and verification of cement content, ensuring outcomes that are both repeatable and predictable.

A8. Risk Reduction and Suitability

Cement stabilisation transforms variable soils into a controlled engineering material, which:

- Reduces uncertainty in settlement performance
- Minimises long-term serviceability risk
- Provides confidence to designers, clients, and approving authorities

When constructed in accordance with the relevant specifications, cement-stabilised layers offer a robust, low-risk foundation solution suitable for a wide variety of engineering applications.

A9. References

- BS 1377 – Methods of test for soils for civil engineering purposes
- BS EN 14227 – Hydraulically bound mixtures
- CIRIA C574 / C638 – Ground improvement guidance
- TRL Report 615 – Performance of cement-stabilised materials