Technical Note 187

Controlled Low-Strength Material for Pipe Installation

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Queensland Government

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1 Introduction

This Technical Note describes the use of Controlled Low-strength Material (CLSM) as an alternative to standard backfill material during pipe installation. Controlled Low-strength Material is a high-flow cement-treated granular material, also known as flowable fill.

As a high-flow material it has the advantage over regular backfill materials that compaction is not required, therefore:

a) Reducing labour effort

b) Increasing consistency of fill performance, and

c) Allowing for reduced trench dimensions.

2 Standard requirements

To place the use of CLSM in context, backfilling of pipe culverts is governed by MRTS04 which lists the following requirements (Clause 19.3.4):

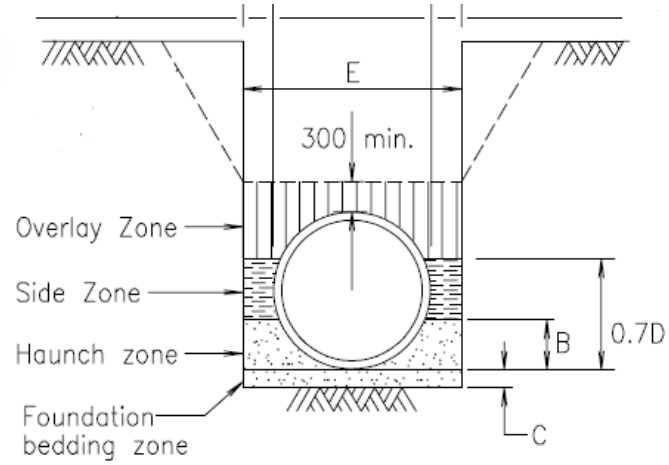
a) Geometry in accordance with Standard Drawing 1359 (Figure 1)

b) Backfill materials in accordance with Clause 19.2.2, 19.2.3 and 19.2.6 for the various zones

c) Compaction in accordance with Clause 15

The compaction requirements in MRTS04, combined with the geometric requirements of SD1359 equate to a support condition of HS3 as defined by AS/NZS 3725.

Figure 1 – Backfill zones (from SD1359)



3 Material requirements for CLSM

Controlled low-strength material for pipe culvert installation shall comply with AS 1379, achieving a 28-day compressive strength in the range of 1.5 to 2 MPa. Aggregate shall be graded to achieve sufficient flow without segregation. The recommended nominal slump is 200 mm[1].

[1] Cement, Concrete and Aggregates Australia, *Controlled Low-Strength Material*, April 2008

4 Placement requirements for CLSM

Controlled low-strength material shall replace the standard backfill material in the haunch and side zones. Optionally, it may also be used as backfill in the overlay zone. Foundation bedding shall remain as compacted backfill.

CLSM shall be placed at an adequate slump and in accordance with the supplier's instructions to ensure adequate density and complete filling of the haunch and side zones.

Fill shall reach adequate strength prior to continuing backfilling or embankment operations. Traffic loads shall not be applied over the pipe for at least 3 days.

5 Practical and design considerations

The use of CLSM has some disadvantages over compacted backfill which must be addressed. As noted above, construction stages must be delayed until the CLSM has reached an appropriate strength. The buoyancy of larger pipes must also be considered and countermeasures enacted. These may include the use of ballast (e.g. sand bags) or chocks, or sequential lifts of fill.

The third consideration concerns the calculation of the required load class of pipe, and the chosen input factors. When replacing standard backfill with CLSM, the bedding factor (F) shall be set as 2.5 (equivalent to HS2). When using CLSM in the overlay zone, the weight of fill shall be adjusted to incorporate the CLSM, and all settlement effects shall be ignored.

6 Detailed explanation of design considerations

The methodology for determining pipe load classes is described by AS/NZS 3725 *Design for Installation of Buried Concrete Pipes*. While this standard includes some material on CLSM (Appendix A), it is ambiguous as to how it should be implemented in practice. Therefore, this Technical Note has specified a bedding factor to provide certainty. To understand the significance of this choice, it is necessary to discuss the relevant design equations.

The load class is determined from a proof load (T_c), itself a function of applied loads (W) and bedding factors (F):

$$T_c = {W_g}/{F} + \sum {W_q}/{F_q}$$ (AS/NZS 3725 Eq. 8)

For this discussion the live loads (W_q) can be ignored, leaving only the dead load of the fill.

The bedding factor compares the insitu support condition to the (harsher) testing support condition. Research[2] into bedding factors for CLSM indicates a bedding factor equivalent to a second-tier support condition[3] is appropriate, with support improving with time as the CLSM strengthens.

The loads due to fill (W_g) only consider fill above the crown of the pipe, so if CLSM is not used in the overlay zone, these do not change. If however the CLSM is used above the level of the pipe (noting this is only possible in a trench), any assumptions about differential soil settlement are negated so Equation 1 of AS/NZS 3725 reverts to $W_g = w_s B H_s + w_c B H_c$ where subscript s indicates soil and subscript c indicates CLSM.

[2] McGrath, T.J. and Hoopes, R.J., "Bedding factors and E' Values for Buried Pipe Installations Backfilled with Air-Modified CLSM," *The Design and Application of Controlled Low-Strength Materials (Flowable Fill), ASTM STP 131*, A.K. Howard and J.L. Hitch, Eds., American Society for Testing and Materials, 1998

[3] Literally "Class B, or SIDD Type 2". Australia's HS2 support condition is roughly equivalent.