Guideline

Structural design procedure for triple blend stabilised subbase

June 2021

Queensland Government

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1 Introduction

Subbase stabilisation can be defined as a means of enhancing soil strength and stiffness properties by adding a hydraulic binder (substances which harden to form a strong building material following the addition of water) such as lime or cement. Correctly designed and constructed, subbase stabilisation can also decrease the subbase's water sensitivity.

The design procedures in this guideline are intended for insitu materials that are stabilised with a triple blend stabilising agent – that is, lime, cement (GP) and flyash.

Transport and Main Roads' established testing protocol and mix design procedure is available and should be applied to determine the optimum amount of lime / cement / flyash additive required to successfully stabilise the insitu subbase materials.

Ideally, the total thickness of subbase to be insitu stabilised should be between 300mm to 350mm. At this depth, subgrade materials may be incorporated into the insitu stabilised subbase layer. This is quite common and, provided there has been adequate material sampling and laboratory testing, incorporating subgrade materials should not be purposely avoided.

2 Purpose

The aim of this guideline is to specify the structural design procedure to be applied when using a triple blend stabilised subbase as a permanent structural pavement layer.

3 Referenced documents

This guideline should be read in conjunction with the following documents listed in Table 3.

Table 3 – Referenced documents

Reference	Title
Austroads *Guide to Pavement Technology Part 4D: Stabilised Materials*	Provide details on: • the types of stabilisation undertaken to improve pavement materials and earthworks materials • the types of binders used in stabilisation • the types of binders suitable for particular materials, and • the laboratory determination of the type and quantity of binder required to achieve a particular type of stabilised material (mix design).
Guideline *Structural design procedure for lime stabilised subgrade*	Details the structural design procedure to be applied when designing a lime stabilised subgrade as a permanent structural pavement layer (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavements-guidelines)
Materials Testing Manual	*Materials Testing Manual Part 2 Application, Section 3 Testing of materials for insitu cement or cementitious blend stabilisation* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Materials-testing-manual)
MRTS07B	Technical Specification *Insitu Stabilised Pavements using Cement or Cementitious Blends* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Specifications)
Pavement Design Supplement	*Supplement to Part 2: Pavement Structural Design of the Austroads Guide to Pavement Technology* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavement-design-supplement)

Reference	Title
Pavement Rehabilitation Manual	Provides guidance and gives requirements for the evaluation of existing pavements and design of rehabilitation treatments for road infrastructure projects. (see www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavement-Rehabilitation-Manual)
TN192 *Pavement rehabilitation - investigation and analysis*	Provides guidance to Project Managers, pavement designers and pavement material testing personnel and Contractors on how to assess the available pavement information and site conditions to plan and undertake pavement investigation work more accurately and efficiently. (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Technical-Notes)

4 Information

When mixed with suitable soils at the correct proportions (or additive content), lime / cement / flyash provides a soil stabilisation effect.

Soil stabilisation can take place in soils containing a proportion of clays, silts, sands and gravels with appropriate mineralogy to produce long-term permanent strength gains. Effective triple blend stabilisation requires the selection of a suitable ratio of additives (lime / cement / flyash) to cater for the wide spectrum of insitu materials. A longer curing time than cement (GP or GB) stabilisation is typically needed to develop the full strength.

Triple blend stabilisation benefits the soil initially through drying, with the cement component gaining early strength through the rapid hydration reaction which quickly decreases the insitu moisture, whereas the lime / flyash components provide a long-term strength gain which reduces the shrinkage, swelling and plasticity of the insitu soil, thus mitigating the effects of prolonged soaking.

Triple blend subbase stabilisation also has a number of design and constructability advantages, including:

- improved pavement support which will reduce the overlying pavement layer thickness, thus lowering material and cartage costs
- a greater range of material types that can be insitu stabilised (a blend of clays, silts, sands and gravels)
- reduced excavation by mixing existing base and/or subbase granular materials with subgrade and fill materials
- option to pulverise and spread the existing pavement materials into a widening, followed by full width insitu triple blend subbase stabilisation to create a uniform subbase support condition
- recycling and reuse of existing base, subbase, fill and subgrade materials, thus reducing excavation, materials, cartage and wastage costs
- longer working times than cement (GP or GB) stabilisation
- option to undertake a 'deep treatment' by incorporating lime beneath the subbase layer to improve the anvil strength and, thus, allow for the successful construction of the triple blend stabilised subbase

- allowance for a two-stage process when incorporating the triple blend additive:
  1. Day 1: spread and incorporate the lime additive component and ameliorate overnight, then
  2. Day 2: spread and incorporate the cement / flyash additive component.

  This two-stage process has been successful in the treatment of insitu material blends with high plasticity and high moisture contents (near or above their optimum moisture content).

5 Design parameters

5.1 General

Stabilising with a triple blend additive provides a number of pavement performance benefits, including:

- greater durability as the effect of the plasticity is reduced
- improved strength
- less susceptible to rutting
- reduced permeability and moisture ingress potential
- reduced water sensitivity, and
- generally, less cracking potential than cement (GP or GB) stabilised materials.

It is crucial that adequate material sampling and laboratory testing is undertaken prior to the commencement of construction works to confirm the suitability and mix design for triple blend stabilisation.

Triple blend stabilisation can be considered when the insitu host materials have sufficient amount of clay, silt, sand and gravel portions for the lime / cement / flyash to react with. This typically requires the insitu host materials to have the following properties:

- Plasticity Index (PI) between 10–20%, and
- ≥ 25% passing the 0.425 mm sieve.

It has been found that, in some cases, insitu materials with a PI > 20% can be suitable for triple blend stabilisation.

For testing purposes, insitu materials need to be sampled and subsequently blended in the same proportions as to be expected during the insitu stabilisation process; for example, if a 300 mm thick triple blend subbase layer is to be stabilised at -200 mm to -500 mm below finished surface level, then the blending of the sampled base, subbase and subgrade materials must reflect what will be encountered at -200 mm to -500 mm. Particle size distribution and Atterbergs laboratory testing is then undertaken on the blended materials to select the most suitable triple blend additive ratio using Table 5.1.

Table 5.1 –Typical additive ratio selection for triple blend stabilised subbase

Linear shrinkage (LS)	Triple blend additive ratio
≤ 6%	30% lime, 40% cement, 30% flyash
> 6%	40% lime, 30% cement, 30% flyash

After classifying the insitu host materials, unconfined compressive strength (UCS) testing is undertaken to determine the mix design (also referred to as the design additive content by mass (%)).The design additive content of the lime / cement / flyash is the amount required to achieve a target UCS range of 1.0–2.0 MPa at 28 days. Ideally and if possible, a target UCS range of 1.0–1.5 MPa at 28 days would further alleviate any cracking potential.

Once the design additive content has been chosen, the allowable working time should then be determined using the selected design additive content.

Refer to TN192 *Pavement rehabilitation Investigation and analysis* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Technical-Notes) and *Materials Testing Manual Part 2 Application Section 3 Testing of materials* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Materials-testing-manual) for insitu cement or cementitious blend stabilisation for further details on material sampling, laboratory testing and mix design.

5.2 Suitability for triple blend stabilised subbase

Appropriate uses for triple blend subbase stabilisation include the following:

- where the materials to be stabilised are suitable (for example, have enough suitable pozzolans, the amount of organic carbon is not excessive), and
- for treatment of pavement and subbase materials within existing pavements, only where removal and replacement (or reinstatement) of the existing pavement can be tolerated (for example, in terms of traffic management and cost).

Triple blend stabilisation can be adversely affected by any of the following deleterious materials:

- a lack of suitable pozzolans
- the presence of excessive organic carbon
- the presence of soluble Sulphates, and/or
- the presence of highly weathered soils with high ferric oxide levels (for example, some lateritic soils).

Stabilisation of unsuitable soils can lead to serious problems which, at times, can only be rectified by removing and replacing the stabilised materials. If such problems occur, the overlying pavement layers must be removed. This can be a very expensive consequence of simply not undertaking adequate and appropriate materials testing.

5.3 Requirements for triple blend stabilised subbase

Where a triple blend stabilised subbase is used:

- There shall be only one monolithic layer of triple blend stabilised subbase. Multiple layers of triple blend stabilised subbases shall not be constructed for road pavements as multiple thin layers are significantly more prone to fatigue as compared to a single monolithic layer.
- The preferred thickness of the triple blend stabilised subbase layer shall be 300–350 mm.

Reference should also be made to Transport and Main Roads' *Pavement Rehabilitation Manual* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavement-

Rehabilitation-Manual) and Technical Specification MRTS07B *Insitu Stabilised Pavements using Cement or Cementitious Blends* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Specifications) for construction requirements.

5.4 Structural design parameters

Based on Transport and Main Roads' field research, refinement of the mix design methodology, the department's *Guideline Structural design procedure for lime stabilised subgrade* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavements-guidelines) and improvements to the construction process detailed in Technical Specification MRTS07B *Insitu Stabilised Pavements using Cement or Cementitious Blends*, the department has developed a structural design procedure to help to exploit the structural benefit provided from a triple blend stabilised subbase.

Like lightly bound materials, triple blend stabilised layers target a UCS range of 1.0–2.0 MPa. Further to this, the behaviour of triple blend stabilised layer can be considered similar to a lightly bound subbase or improved layer.

The lightly bound structural design approach outlined in Table 6.8(b) of the *Pavement Design Supplement* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavement-design-supplement) shows that, for a lightly bound subbase or improved layer manufactured with a lower quality granular host material, a vertical modulus of 210 MPa applies, regardless of the thickness and modulus of the overlaying bound materials and the underlying support conditions.

Similarly, referring to the *Guideline Structural design procedure for lime stabilised subgrade*, a vertical modulus of 210 MPa applies for lime stabilised layers, regardless of the thickness and modulus of the overlaying bound materials and the underlying support conditions.

Considering these two structural design approaches (lightly bound and lime), triple blend stabilised subbase can be designed in a similar manner. Therefore, for the purposes of mechanistic-empirical design, triple blend stabilised subbase shall be modelled with the following parameters shown in Table 5.4.

Table 5.4 – Design parameters of triple blend stabilised subbase

Design Modulus	Poisson's Ratio	Degree of anisotropy	Sublayering
210 MPa	0.45	2	NOT sublayered[1]

Note:

[1] Apply a single vertical design modulus for the full depth of the triple blend stabilised subbase layer.

In designing the pavement thickness, permanent deformation is assessed using the vertical compressive strain at the top of the underlying untreated subgrade, rather than at the top of the triple blend stabilised subbase layer.

5.5 Minimum overlying pavement thickness

The minimum overlying pavement thickness shall be as per the requirements of Table 5.5.

Table 5.5 – Minimum pavement thickness overlying triple blend stabilised subbase

Average daily ESA in design year of opening	**Minimum pavement thickness overlying triple blend stabilised subbase (mm)**
< 100	150
100–1000	200
1000	250