DELIVERING FOR QUEENSLAND

Guideline

Structural design procedure for triple blend stabilised subbase

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Queensland Government

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1 Introduction

This guideline details the structural design procedure for the insitu stabilisation of existing pavement materials using a triple blend stabilising agent (that is, lime, cement (GP) and flyash) to create a strong, resilient, and homogeneous subbase layer.

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, cement and/or flyash. Correctly designed and constructed, a triple blend stabilised subbase can reduce the subbase's moisture sensitivity and provide a strong anvil (or support) to the overlying pavement layers.

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

Ideally, the thickness of the insitu triple blend stabilised subbase layer should be between 300 mm to 350 mm. At this depth, subgrade materials may be incorporated into the insitu stabilised subbase layer. This is considered commonplace 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 detail the structural design procedure when adopting a triple blend stabilised subbase as a permanent 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
_	*Pavement Investigation and Analysis*, Transport and Main Roads (see https://www.tmr.qld.gov.au/business-industry/technical-standards-publications/pavements-guidelines)
-	*Structural design procedure for lime stabilised subgrade*, Transport and Main Roads (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavements-guidelines)

Reference	Title
-	*Materials Testing Manual*, Transport and Main Roads Refer to Section 8 of *Materials Testing Manual*, Part 2 (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Materials-testing-manual)
MRTS115	*Insitu Stabilised Subbases using Triple blend,* Transport and Main Roads *(*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*, Transport and Main Roads (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavements-guidelines)
Pavement Rehabilitation Manual	*Pavement Rehabilitation Manual*, Transport and Main Roads (see www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavement-Rehabilitation-Manual)

4 Background

4.1 Stabilisation

When mixed with suitable soils in the correct proportions (or content), triple blend stabilising agent (lime / cement / flyash) provides a soil stabilisation effect.

Triple blend stabilisation can take place in soils containing proportions of clays, silts, sands, and gravels with appropriate mineralogy to produce long-term permanent strength gains.

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. 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.

A longer curing time than cement (GP or GB) stabilisation is typically needed to develop the full strength.

4.2 Benefits

Subbase stabilisation with triple blend provides a number of benefits to the host soil's properties, including:

- greater durability as the effect of the plasticity is reduced
- improved strength

- less susceptible to rutting / deformation
- reduced permeability and moisture ingress potential
- reduced water sensitivity, and
- generally, less cracking potential than cement (GP or GB) stabilised materials.

The department has recently undertaken research that indicates triple blend additive can be used to effectively manage slaking and dispersive soils. For further information regarding the use of triple blend to manage slaking and dispersive soils, email Technical Publications.

4.3 Design and constructability advantages

Subbase stabilisation with triple blend 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 materials with subgrade and/or fill materials
- minimise the exposure and subsequent treatments weak (or soft) existing (or natural) subgrade materials
- option to pulverise and spread the existing pavement materials into a widening, followed by full width insitu triple blend stabilisation to create a homogenous subbase support condition
- recycling and reuse of existing base, subbase, fill and subgrade materials, thus reducing excavation, cartage and wastage costs
- longer working times than cement (GP or GB) stabilisation
- permit a two-stage process when incorporating the triple blend stabilising agent:
  - Day 1: spread and incorporate the lime stabilising agent component and ameliorate overnight, then
  - Day 2: spread and incorporate the cement / flyash stabilising agent component.

    This two-stage process has been successful in the treatment of materials with high plasticity and high moisture contents (near or above their optimum moisture content).
- ability to undertake a 'deep' insitu stabilisation subgrade treatment by incorporating lime beneath the subbase layer to improve the strength of the anvil allowing for the construction of the triple blend stabilised subbase layer.

4.4 Mix design

Insitu triple blend stabilisation of a subbase will typically involve the mixing of different materials within the existing pavement profile, including base, subbase, fill and/or subgrade materials. Effective triple blend stabilisation requires the selection of a suitable ratio of additives (lime / cement / flyash) to cater for the range of insitu materials. Determining the optimal ratio of lime, cement, and fly ash together with the additive content is key to achieving the desired long-term performance.

It is imperative 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. During the pavement investigation, the designer needs to consider the feasibility of triple blend stabilised subbase and ensure that sufficient samples of the pavement and subgrade materials are collected for laboratory mix designs.

For testing purposes, insitu materials need to be sampled and subsequently blended in the same proportions as to be encountered 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.

In some situations, the triple blend stabilised subbase layer might require the incorporation of imported materials. Examples of these situations include, grade-line adjustments, widening of existing pavement and specific needs related to improving the properties of the insitu materials.

The different materials can be blended together by percentage of volume or dry mass to achieve a representative sample ready for the mix design.

Particle size distribution and Atterbergs laboratory testing is then undertaken on the blended materials. Triple blend stabilisation can be considered when the insitu materials have sufficient clay, silt, sand, and gravel portions for the lime / cement / flyash to react with. This typically requires the insitu materials to have the following properties:

- Plasticity Index (PI) between 10–20% (in some cases, insitu materials with a PI > 20% or < 10% may be suitable), and
- ≥ 25% passing the 0.425 mm sieve.

After classifying the insitu materials, the most suitable triple blend additive ratio is selected using Table 4.4 as a guide.

Table 4.4 – Typical additive ratios for triple blend stabilised subbases

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

After selecting the triple blend additive ratio, 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 between 1.0–2.0 MPa at 28 days. Ideally and if possible, a target UCS range between 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 be determined using the selected design additive content.

Refer to Guideline *Pavement Investigation and Analysis* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavements-guidelines) and Section 8 of *Materials Testing Manual*, Part 2 (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavements-guidelines) for further details on material sampling, laboratory testing and mix design.

4.5 Material suitability

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 performance issues 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 laboratory testing.

5 Structural design

5.1 Thickness

Where a triple blend stabilised subbase is used:

- The preferred thickness of the triple blend stabilised subbase layer shall be 300 to 350 mm
- 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 compared to a single monolithic layer.

Reference should be made to the department's *Pavement Rehabilitation Manual (*see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavements-guidelines) and Technical Specification MRTS115 *Insitu Stabilised Subbases using Triple blend* (see https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Pavements-guidelines) for construction requirements.

5.2 Structural design parameters

Based on the department's historical 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 MRTS115 *Insitu Stabilised Subbases using Triple blend,* the department has developed a structural design procedure 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 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 material, a vertical modulus of 210 MPa applies, regardless of the thickness and modulus of the overlaying 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 materials and the underlying support conditions.

Therefore, for the purposes of mechanistic-empirical design, triple blend stabilised subbase can be modelled with the following parameters shown in Table 5.2.

Table 5.2 – Design parameters of triple blend stabilised subbase

Design Modulus	Poisson's Ratio	Degree of anisotropy	Sub-layering
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.

5.3 Minimum overlying pavement thickness

The recommended minimum overlying pavement thickness is shown in Table 5.3.

Table 5.3 – 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 to 1000	200
> 1000	250