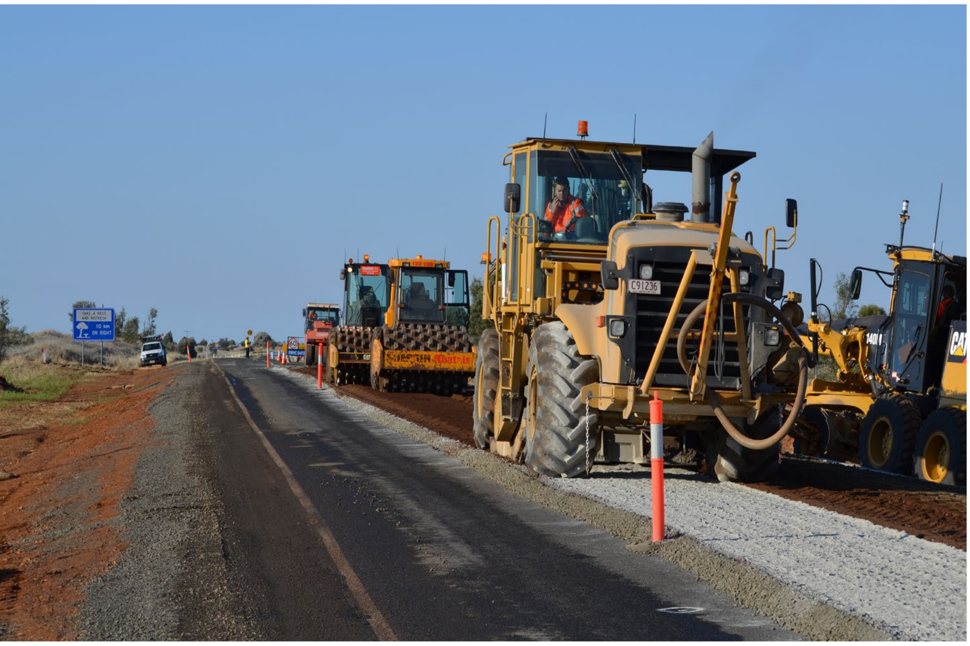

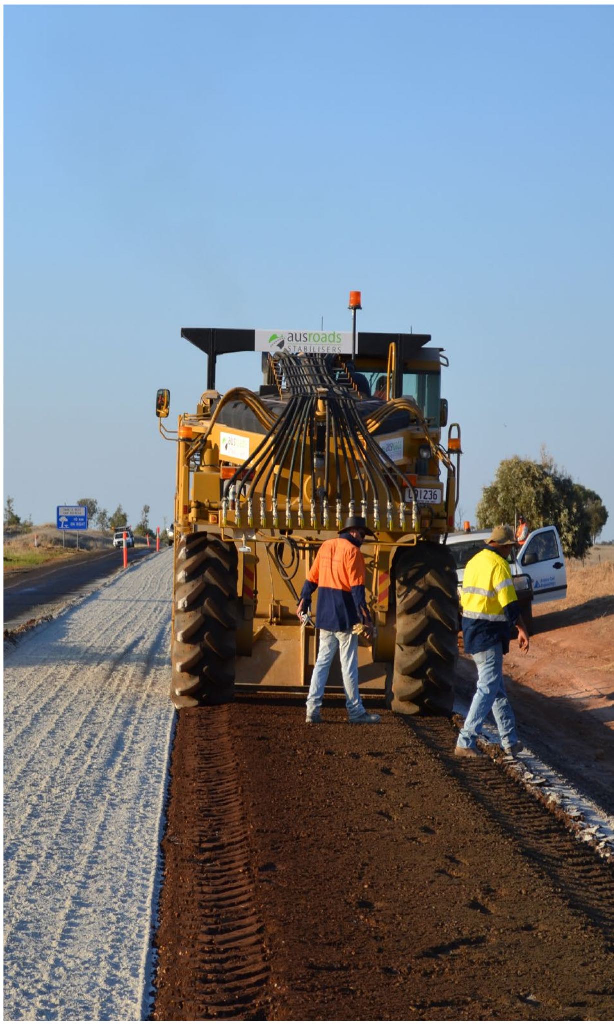

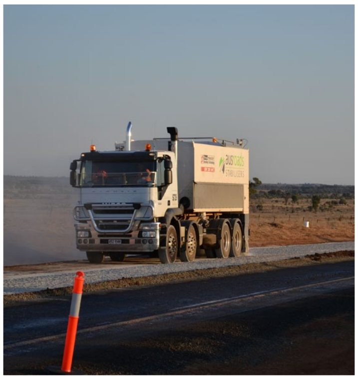

FEEDLOT DESIGN AND CONSTRUCTION

18. Pen and road stabilisation

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Introduction

Stabilising pen surfaces to provide a solid surface improves animal welfare by minimising contact between resting animals and wet mud and manure. Road subgrade or road surfaces may be stabilised to increase strength and durability or to prevent erosion and dust generation.

Pen surfaces may be stabilised during the initial construction or as a remedial action after the surface has broken down. Surface material stabilisation involves altering the properties of one or more materials, by mechanical or chemical means, to improve the desired engineering properties. The effect of a hard cement-stabilised surface on animal movement is not known.

The materials available for feedlot construction vary between regions and all may have different engineering properties. These materials have to be tested to establish suitable chemical additives and admixture rates to achieve the desired engineering properties.

The method of stabilisation selected should be verified in the laboratory before specifying or ordering materials, and certainly before construction. For example, the in-situ material may have low loadbearing strength because of an excess of clay, silt or fine sand. Within a reasonable distance, suitable granular materials may occur that may be blended with the existing in-situ material to achieve the design specification at a much lower cost in manpower and materials than importing material for surfacing.

Liquid dust suppressants have been used for unsealed roads. Whilst some dust suppressants may provide short term solutions to dust generation, they are invariably applied from the surface and not mixed with the surface materials. Hence, the use of externally applied dust suppression is not stabilisation. Applying dust suppressants from a moving water cart uses a far larger amount of product than incorporating them into the surface material inside a mixing chamber. For the material specifications and tests required please refer back to Section 17 – *Pen and road surfaces*.

Design objectives

The objective of stabilising pen and road surface material is to

- blend available materials so that, when properly compacted, they give the desired stability
- provide a hard surface to minimise damage when pen cleaning
- withstand the bearing weight of cattle and pen cleaning equipment
- be durable and resist damage from cattle pawing and licking
- minimise gravel loss and dust from feedlot roads
- reduce frequency of pen and road maintenance
- utilise in-situ materials and/or readily available local materials
- withstand the anticipated traffic loads and frequencies
- prevent or minimise adverse impacts on groundwater and surface waters
- selectively improve high wear areas (e.g. behind feed bunks, around water troughs).

Mandatory requirements

Compliance with

- National Guidelines for Beef Cattle Feedlots in Australia (MLA, 2012a)
- National Beef Cattle Feedlot Environmental Code of Practice (MLA, 2012b)
- relevant Commonwealth, state and local authority codes, regulations and relevant Australian standards as applicable to the feedlot development.

The National Guidelines for Beef Cattle Feedlots (MLA, 2012a) state that

- If a groundwater assessment indicates a high potential for contamination of underground water resources because of leaching of nutrients through permeable, underlying rock strata, a impermeable barrier will be needed between the contaminant and the groundwater. This is required if the permeability of underlying soil/rock strata exceeds 0.1 mm/day.
- Clay liners should have a maximum permeability of 1×10^{-9} m/s (~0.1 mm/day) for distilled water with 1 m of pressure head.

Design choices

Material can be stabilised many ways but all can be categorised as

- mechanical stabilisation, or
- chemical stabilisation.

Some stabilisation techniques use a combination of the two methods.

Mechanical stabilisation relies on physical processes to stabilise the material, either altering the physical composition of the material (blending) or placing a barrier in or on the material to obtain the desired effect.

Chemical stabilisation relies on the use of a binder to alter the chemical properties of the material to achieve the desired effect (such as using lime to reduce a material's plasticity).

A pug mill machine is a continuous mixer commonly used for obtaining a dense, well-graded, uniformly mixed material.

Mechanical stabilisation

Mechanical stabilisation through material blending or screening is the most economical and expedient method of altering the existing material. When material blending is not feasible or does not produce a satisfactory result, geotextiles, soil reinforcing or chemical admixture stabilisation should be considered. If chemical stabilisation is being considered, determine what binders are available for use and any special equipment or training.

Mechanical stabilisation is valuable but has limitations. The principles of mechanical stabilisation have frequently been misused. For example, clay has been added to 'stabilise' soils when adequate compaction would be sufficient; understanding the densification that can be achieved by modern compaction equipment should prevent a mistake of this sort. In the same way, poor trafficability of a material during construction because of a lack of fines should not necessarily provide an excuse for mixing in a clay binder.

Chemical stabilisation

Chemical products are often used to stabilise material when mechanical methods of stabilisation are inadequate or when replacing an undesirable material with a desirable material is not possible or is too costly. Nearly all chemical stabilisers fall into one of the following categories

- cement
- lime
- bituminous materials.

Collectively, these materials are usually referred to as binders. In Australia, most binders used for stabilisation are in a powder form, with bitumen being the main liquid binder. Sometimes additives are used with binders to enhance the construction process or provide additional long term properties to the stabilised material.

When selecting a binder, consider the following factors

- type of material to be stabilised
- purpose for which the stabilised layer will be used
- level of material quality improvement desired
- required strength and durability of the stabilised layer
- cost
- environmental conditions.

Spreader truck used for spreading dry binder agent onto base material.

A 'modified' material will typically incorporate a small amount of a binding agent such as lime, whereas a 'stabilised' material will incorporate a larger amount of binding agents such as cement, fly ash or slag, alone or in combination. There is no internationally recognised and consistent definition which clearly establishes the difference between a 'modified' material and a 'stabilised' material. Typically, a 'modified' material will have a Unified Compressive Strength (UCS) of less than 1 MPa and a 'stabilised' material will have a UCS of above 1 MPa.

The decision to modify or stabilise a material is the choice of the designer and is usually based on local experience.

A material safety data sheet (MSDS) should be obtained for the stabilising material before use.

The permeability characteristics of the stabilised material can be altered. Permeability can be affected by the mixing method (wet or dry), the type and amount of binder, the time after mixing and the initial characteristics of the original material. For example, the addition of lime to a clay soil flocculates the clay soil particles and increases the permeability, whereas the addition of Portland cement reduces the soil's natural permeability.

Cement

A wide range of cement and cement blends can be used as an effective stabiliser for a wide range of materials and situations. Cement blends are effective stabilising binders and can affect material behaviour by

- greatly reducing the moisture susceptibility of some soils, giving enhanced volume and strength stability under variable moisture conditions

- causing the development of interparticle bonds in granular materials, increasing the tensile strength and stiffness of the stabilised material.

There is a range of commercially produced cement types and blends, each with different properties and characteristics. The principal cement types available are

- Type GP – general purpose Portland cement
- Type GB – general purpose blended cement

GP cements are produced from a mixture of calcium carbonate, aluminia, silica and iron oxide which, when calcined and sintered at high temperatures, gives a new group of chemical compounds capable of reacting with water. The composition of individual cements can vary depending on the nature and composition of the raw materials being used.

GB cements contain a combination of Portland cement with additives such as lime, fly ash, aslag (ground granulated blast furnace slag) and silica fume.

Blends are now preferred because they have

- slower setting times, resulting in a stronger final material
- longer working time
- greatly reduced chance of cracking

They also use recycled products and so are better for the environment.

Not all blends are available in all locations in Australia.

If the temperature during construction is less than about 5°C, the necessary chemical reactions are slower and the strength gain of the cement-material mixture will be minimal. Cement-material mixtures should be scheduled for construction during climatic conditions that will allow sufficient durability to be achieved, or another stabiliser should be considered for use.

Heavy vehicles should not be allowed on the cement-stabilised material before a 10–14-day curing period to prevent damage.

Portland cement can be used either to modify and improve the quality of the material or to transform the material into a cemented mass, which significantly increases its strength and durability. The amount of cement additive depends on whether the material is to be modified or stabilised, and can range from less than 4% to 16% of the dry weight of soil.

Water for cement stabilisation should be clean, free from organic material and contain less than 0.05% sulphates. The water source for curing cement stabilised materials should also be assessed; saline water can cause a build up of surface salts which can interfere with the adhesion of future seal coats.

Finely-graded gravels, clayey gravels, silty sands (>50% passing 425 µm sieve) and other materials without significant particle interlock are not suitable for use with cement binders. The life of these materials will generally be short and the surface will rapidly disintegrate with the onset of cracking.

Spreader truck spreading dry binder agent onto base material.

Lime

Lime reacts with medium, moderately fine and fine-grained materials to decrease plasticity, increase workability and strength and reduce swelling. Lime is used as a stabiliser for plastic materials whose plasticity indices generally exceed 10. For example, soils classified according to the USCS as CH, CL, MH, ML, SC, SM, GC, and GM should be considered as potentially capable of being stabilised with lime.

Lime can be used either to modify some of the physical properties of a material and thereby improve its quality, or to transform a material into a stabilised mass which then increases its strength and durability. The amount of lime additive depends on whether the material is to be modified or stabilised.

Hydrated or quicklime can be used. Most stabilisation is done using hydrated lime, but quicklime is more effective if the clay has to be dried before compaction. The chosen technique should be based on considerations such as contractor experience, equipment availability, location of site and availability of an adequate nearby water source.

Fly ash

Fly ash is a pozzolanic material that consists mainly of silicon and aluminium compounds that, when mixed with lime and water, forms a hardened cement-like mass capable of obtaining high compression strengths.

Large reclaimer/stabiliser for mixing binder agent into base material

Fly ash is a product of the power generation industry. The type of coal used and the mode of operation of the power plant determine the chemical composition and particle size distribution of the fly ash. Consequently, not all fly ashes are suitable for use as stabilisers. Generally, fly ash derived from burning black coal is high in silica and alumina and low in calcium and carbon, and is well suited for use as a stabiliser. On the other hand, fly ash derived from burning brown coal contains large percentages of calcium and magnesium sulphates and chlorides and other soluble salts, which make it unsuitable as a stabiliser.

Unburned organic carbon breaks the continuity of contact in the cement-like reactions and should be limited to about 10%.

Fly ash used as a stabiliser should conform to AS 3582.1.

A stabilised feedlot surface constructed with a mixture of soil and 15–25% coal combustion fly ash offers the benefits of a very stable surface with relatively low material and construction costs (Anderson et al., 2004)

Before using this process for stabilising feedlot pen surfaces, all organic material, such as topsoil or manure, should be removed from the area.

Fly ash may be mixed externally and then placed on the pen surface, or it can be spread evenly over the loose pen surface and mixed using a set of discs pulled by a tractor. The material should 'roll' off the disc when it is adequately mixed. Moisture may be added to the fly ash during incorporation to minimise dust.

After the final pass of the mixing equipment, the blended material should be compacted to achieve maximum stabilisation. This is best accomplished with a sheepsfoot roller or the tyres of the placement equipment. The stabilised area should be maintained in a moist condition for approximately 5 days and then left for another 5 days before use.

Bituminous materials

Types of bituminous stabilisation are

- soil bitumen – soil cohesive is made water-resistant by admixture
- sand bitumen – sand is cemented together by bituminous material
- oiled earth – unsealed roads made resistant to water absorption and abrasion by spraying slow or medium-curing grade bitumen
- bitumen-waterproofed, mechanically stabilised material – two or more materials are blended to produce a good gradation of particles from coarse to fine. Comparatively small amounts of bitumen are then added, and the material is compacted
- bitumen-lime blend – small percentages of lime are blended with fine-grained materials to facilitate the penetration and mixing of bitumen.

The type of bitumen to be used depends on the type of material to be stabilised, the method of construction and the weather conditions.

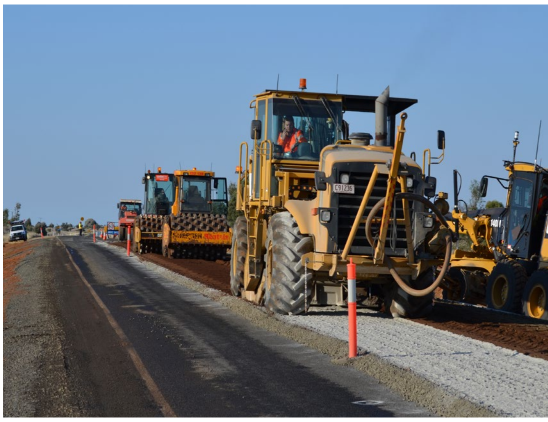
Most bituminous stabilisation is performed in situ with the bitumen being applied directly on the subgrade and/or surfacing materials before immediate mixing and compaction. This type of construction used liquid asphalts (emulsions).

Polymeric stabilisers

Polymers act to repel the moisture from the fines in a host material and thus preserve the dry strength of the material; they are most responsive in soils or gravels containing over 10% silt or clay fines. The process involves the creation of a water-repellent soil matrix between the stones, which reduces permeability and so limits water ingress. By repelling moisture, the characteristics of the dry material can be maintained through soaked conditions. Because the polymer is so strongly attracted to clay, silt and soil particles it competes successfully with water to coat them, and so the softening and lubricating effect of any moisture that does enter the pavement is greatly reduced. This is referred to as 'internal' waterproofing of the fine-grained particles.

Unlike cement blends, polymers do not significantly increase the dry strength of the material. Hence Unconfined Compressive Strength (UCS) testing is not considered appropriate for investigating the benefits of polymer stabilisation. Polymer-modified material will typically have the same rigidity as the dry natural material; however, by keeping the water out of the material, it achieves greatly increased soaked CBR values and some increase in soaked UCS strengths.

In unsealed roads, stabilisation of materials with polymers reduces the potential for rutting after periods of wet conditions.



Stabiliser machine mixing binder agent into road base material. The mixed material is being compacted immediately by the sheepsfoot compacters.

Suitability of additive to soil type

Construction specifications usually specify two items. Firstly what binder to use and secondly, how much of it. Table 1 provides a broad guide as to the suitability of various binders to various host materials.

Table 1. Suitability of binder of soil type

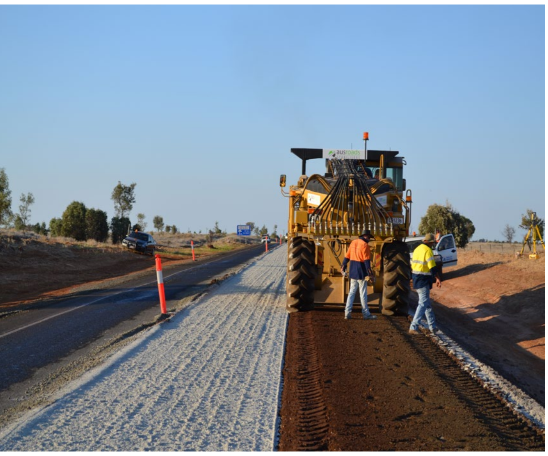
Binder	Crushed rock	Well-graded gravel	Silty/clayey gravel	Sand	Sandy/silty clays	Heavy clays
Cement	Usually very suitable	Usually very suitable	Usually very suitable	Usually satisfactory	Usually satisfactory	Usually not suitable
GB Cement	Usually very suitable	Usually very suitable	Usually very suitable	Usually very suitable	Usually very suitable	Usually satisfactory
Cement blends	Usually very suitable	Usually very suitable	Usually very suitable	Usually very suitable	Usually very suitable	Usually not suitable
Lime	Usually satisfactory	Usually satisfactory	Usually very suitable	Usually not suitable	Usually satisfactory	Usually very suitable
Lime and cement	Usually not suitable	Usually not suitable	Usually not suitable	Usually not suitable	Usually satisfactory	Usually very suitable
Lime and fly ash	Usually not suitable	Usually very suitable	Usually very suitable	Usually not suitable	Usually satisfactory	Usually satisfactory
Bitumen	Usually very suitable	Usually very suitable	Usually satisfactory	Usually satisfactory	Usually not suitable	Usually not suitable
Bitumen/cement blends	Usually very suitable	Usually very suitable	Usually satisfactory	Usually satisfactory	Usually not suitable	Usually not suitable
Insoluble polymers	Usually satisfactory	Usually very suitable	Usually very suitable	Usually not suitable	Usually very suitable	Usually satisfactory

Usually very suitable
Usually satisfactory
Usually not suitable

Construction considerations

Successful stabilisation using any additive requires the use of purpose-built spreading and mixing equipment.

When materials are required to be stabilised, the stabiliser binder is either dry spread with spreader trucks followed by the use of a stabilising machine, or fed through a dedicated mixing plant (pug mill). Within these plants, the granular material is fed into a mixing chamber where water and binders are added in a set sequence to allow uniform dispersion of moisture and binding additives. The even mixing and distribution of the binders is important to the ongoing performance of the pen and/or road surface. The amount of stabilising binders added can be based on the percentage either by weight or volume, depending on the equipment used. Mixing should not be attempted with other earthmoving or paving equipment.



Stabiliser machine mixing binder agent into road base material.

The spreaders should be enclosed protecting the additive from the weather, and have accurate, variable distribution mechanism.

Stabilised materials must be compacted immediately after spreading in order to obtain their optimum strength and performance.

Specification compliance

The design performance of stabilised materials is not measured by the percentage of binder added to the material, but rather by separate testing of the material to determine its Unconfined Compressive Strength (UCS).

The UCS involves the compaction of the stabilised surface material at the correct moisture content, curing and crushing under controlled laboratory conditions, and thus provides a repeatable measure of the compressive strength of the material.

Specification compliance often requires a modified or stabilised material to achieve a minimum UCS value. As pen and road surface materials can be produced from many geological types from various sources, the required UCS may be achievable with a low percentage of binder for one material, but need a significantly higher percentage for another. For this reason, compliance is normally measured not on the percentage of binder added, but by the achievement of the UCS test.

Quick tips

- In-situ material may have low load-bearing strength because of an excess of clay, silt or fine sand. Stabilisation can be used to achieve the design specification at a much lower cost than importing the correct material.
- Material may be stabilised to increase strength and durability or to prevent erosion and dust generation.
- Do not confuse material binders and dust suppressants. Dust suppressants provide short-term solutions to reduce the generation of dust from pens and/or roads and are not typically mixed with the surface materials.
- Seek specialist advice if stabilisation is being considered.
- Poor trafficability or compaction of a material during construction should not necessarily provide an excuse for adopting material stabilisation.
- Normal basic material parameters such as MDD, OMC, grading and PI should be determined on the in-situ material to aid the selection of the most appropriate binder.
- Binders are admixtures used for chemical stabilisation.
- Pen and road surfacing specifications should specify what binder and how much to use.
- Lime is used to modify plasticity properties of high plastic clays to increase workability and strength.
- Cement-like binders give best results with low plasticity materials (e.g. gravels).
- Not all fly ash is suitable as a stabilising agent.
- In modified or stabilised materials the clock is ticking from the time cement binders touch water in the mixing chamber of the mixing plant. The time of hydration is the time available to apply it to the surface and compact it.

Further reading

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