STABILISATION OF UNSEALED ROADS

Greg White
Chief Executive Officer, AustStab, NSW Australia

And

Andrew Middleton
Engineering Manager, Stabilised Pavements of Aust., NSW Australia

Paper Summary

Rural councils share similar road rehabilitation requirements in many areas of Australia. It is important with unsealed roads being over 50% of the road network that their maintenance both optimises safety, user comfort and cost. There is also more pressure for Road Authorities to give acceptable all weather access to freight and other traffic on major arterials during road maintenance.

The presentation describes the latest field research on the stabilisation of unsealed roads.

UNSEALED ROADS

AustStab was provided funding by Department of Transport and Regional Services (DOTARS) to investigate stabilisation to

- Substantially reduce dust generation
- Reduce maintenance frequency and hence cost
- Provide safe all weather access
- Improve the structural strength of unsealed roads

The study has developed a simple design and construction procedure while showing the key advantages of stabilisation as well as the cost savings.

Introduction

Stabilisation of road pavements has been widely used and well documented by road authorities in Australia and overseas. This has mainly been applicable to sealed and heavy duty pavements. However there is little information on stabilisation of unsealed roads.

Unsealed roads often make up over 50% of a council’s road network. With the financial restraints, increased traffic volumes, and weights, local councils are having difficulty satisfying community expectations.

AustStab was engaged by Auslink to research the use of stabilising of unsealed roads.

The main objectives were

- Develop a design and construction procedure for stabilisation of unsealed roads
- Reduce dust
- Produce a safer pavement in wet conditions
- Reduce maintenance costs
- Produce a higher strength pavement

This paper is designed to give a simple step-by-step procedure for the design and construction of stabilised unsealed roads. Combined with knowledge of local materials, engineers will develop a greater understanding of pavement design.

Stabilisation is the addition of binders or other aggregate sources to the local pavement to improve its structural and performance properties.

The binders used in these trials were lime, cementitious and dry powdered polymer (DPP).

Site Investigation

A visual inspection for the full length of the proposed road for rehabilitation should be carried out to assess its variability in materials. Historical information of pavement materials is often available which can be used in the design process.

Unless there is a high variability in pavement type, samples should be taken every 300 – 400 metres. A sample hole should be dug to a depth of the imported material plus 50mm of the natural ground. The hole should have vertical sides with a minimum/maximum depth of 150/200mm.

The layers of different materials should be dug separately and a brief description of each material (colour, clay/silt and aggregate size). The total sample size should be about 40-50 kg.

Often the material that has migrated to the table drains is some of the most suitable material to stabilise. In the construction process this material should be graded back on to the road prior to stabilising. It is important to include some of this table drain material in the sample taken in a similar ratio to the resultant pavement.

If the existent pavement is less than 150 mm and geotechnical or local knowledge indicates the natural material is too reactive or has a poor grading, then a granular overlay of imported material of up to 50mm thick should be considered. This material should also be included in the test sample.

Material design criteria

Sample preparation

The preparation of the sample before mixing should take into consideration the existing depth of the pavement material. If the depth is less than the stabilisation depth, it is recommended that the sample be prepared using a linear proportion of pavement and imported table drain or subgrade materials based on depth.

The first step is to ascertain the type of binder and the binder content. The binder type is usually ascertained by calculating the Plastic Index (PI). The binder content is calculated by testing two binder contents (usually 3% and 5%) of the mixed sample using the Unconfined Compressive

Strength (UCS). The UCS will determine whether there is sufficient binder to react to form a bound pavement material after compaction and 28 day curing. The minimum optimum UCS after the curing period is 1.0MPa, however many successful rehabilitations have been achieved with a UCS as low as 0.5 MPa. Advice should be sought if the UCS is less than 1.0 MPa.

The normal procedure would be to send the prepared samples to a geotechnical laboratory that would carry out the appropriate testing to determine the mix design. AustStab has a mixed design procedure available at www.auststab.com.au.

Binder Selection

The three binders used in the study were:

- lime
- cement/slag blend, and
- dry powdered polymers

It is important to understand the mechanism and properties of each binder.

Lime

Hydrated lime in the presence of water creates an alkaline environment in which the lime will react with any Pozzolans (materials containing reactive silica and alumina). Clays are usually made up of silica and alumina components which react with the lime.

The lime’s reaction is twofold. It firstly agglomerates fine clay particles into coarse friable particles resulting in a dewatering effect. Second, the increased pH encourages chemical reactions that lead to the formation of calcium silicates and aluminates similar to cement reactions. As a result the Plastic Index decreases due to the liquid limit decreasing and the plastic limit increasing. This creates a permanent change in the detrimental clay characteristics.

Cement

Cement however is a combination of lime, silica, alumina and other metal oxides. For this reason cement is self sufficient in the components required to form a cement paste. The primary reaction of cement is with the moisture in the soil which hydrates the components to set up a crystallization which gives increased strength as the crystals interconnect.

In this study a cement blend of portland cement and granulated blast furnace slag was used. Slag has a similar chemical composition to portland cement but in different proportions. The blend of the two components gives a slower setting binder allowing increased working time with reduced shrinkage and therefore less cracking.

Dry Powdered Polymers (in this case Polyroad)

The addition of these polymers creates a soil matrix that is resistant to the detrimental effects of water on pavement material. It reduces permeability and limits water ingress. The polymer is highly attracted to clay, silt and soil particles and competes successfully with water to coat them, therefore 'waterproofing' the pavement. Many road gravels have adequate strength to resist traffic stresses when they are dry but lose strength due to lubrication of larger stones during wet conditions. Polymers reduce this tendency to reduce strength thus maintaining pavement strength in all conditions.

Laboratory Test Regime

1. ***Plastic Index (PI)***
   The clay content is critical to selecting the most suitable binder. As a simple guide the initial binder to be tested should be:

PI	Binder Type
Under 12	Cement
12 or greater	Lime

   It should be noted that some clays or material contaminated with organic matter might not react with the lime to an adequate degree.

2. ***Grading***
   If material appears very coarse, a simple grading should be carried out. If more than 40% is retained on the 19mm sieve then the pavement might be unsuitable for stabilisation without the addition of a finer material. The presence of a high proportion of large aggregate will result in the plucking out of the large stones on the surface causing potholing.

3. ***Unconfined Compressive Strength (UCS) Testing***
   With the binder selected using the PI results then two samples should be made with 3 and 5% binder. It should be noted that in the laboratory hydrated lime is used for safety and convenience. However, it is usual to use quicklime in the field. These two types of lime have different levels of Ca $(OH)_2$, the reactive chemical. Therefore the field quicklime spread rate should be 0.76 times the laboratory design percentage lime. Some lime suppliers have different available lime contents therefore the same supplier should be used in the laboratory and field.

   The UCS testing is carried out using AS1141.54 and has the following requirements:

   - samples are compacted to 100% Standard Compactive Effort
   - curing is carried out for 28 days for all binders, and
   - samples can have a four hour soak if the road is in a rainfall area of more than 300mm pa. This simulates the effects of ingress of water in the worst insitu condition.

   For higher trafficked roads in different rural seasons a UCS of 3 MPa is desirable. For most other roads 1 to 2MPa is suitable. The cost of the binder is often a major design consideration to the chosen binder content. The two UCS results from 3% or 5% can be extrapolated to optimise the binder content. If the maximum UCS is less than 1 MPa, advice should be sought as to the applicability of stabilisation.

Strengths as low as 0.5 MPa show that there has been a reaction with the pavement and therefore will greatly increase the roads durability.

Many councils have similar pavements across their region and practical results from previously stabilised mix designs can be used as a good indication of design and performance. In fact this local knowledge enables testing to be minimised if the different pavement materials are known.

Polymers

Polymers 'waterproof' the pavement rather than adding strength. This waterproofness allows the dry strength of the pavement to be maintained in wet conditions. The best mix design procedure is to test for effects of water on a treated sample of the pavement. The capillary rise test is normally used - if there is a significant improvement with polymer then the sample is suitable for trial.

Construction

It is critical that a dedicated stabiliser/mixer machine is used to ensure thorough mixing of the binder. It is essential that water is metered to ensure optimal moisture content of the stabilised pavement.

If there is loose material in the table drains this should be returned to the pavement prior to stabilisation as this is the material that was previously used in the pavement.

Steps:

1. Trim existing road to shape required.
2. Add imported overlay or table drain material if applicable.
3. Spread binder evenly over width of mixing.
4. If using quicklime – slake lime.
5. Use stabiliser to mix in binder and water – it is important to achieve optimal moisture content.
6. Compaction with smooth drum roller (15 tonnes).
7. Trim surface with grader adding surface moisture as required.
8. Compact again with smooth drum followed by multi tyred roller.
9. Final trim.

Notes:

- Do not use pad foot roller as the depressions will remain, resulting in premature loss of pavement surface.
- Do not bring shoulder material on to already stabilised material. This material should be brought onto the pavement prior to spreading of binder. The introduction of non-stabilised material will cause delamination.
- Crossfall should be minimum 6% to allow for adequate drainage. This is important as adequate drainage is required for a long life. It is appreciated that traffic will flatten the crown over time but sides will remain with a good crossfall.
- Drains should be built to allow water not to pond on pavement or shoulders
- Cracking will often appear especially for cementitious stabilised pavements. This is not a concern as loose material will fill cracks with no deleterious result.

Costs

Binder $2 - $4 /$m^2$

Spread + mixing $0.75 - $1.50 / m^2

Compaction $1.00 / m^2

Productivity of about 6000m^2 / day

Dust

The visual results of stabilising are quite significant with the dust generation greatly reduced. This is the result of the binding of the fine particles in the pavement. Tests have been carried out where a square test section is completely cleaned of all loose material. This is compared with a control unstabilised section of road with similar road materials. The results are shown in the table below.

Site	Binder	Loose Mat kg/m^2
Old Crowa Road (Control section)	NIL	16.3
Old Corowa Road	3% Lime	1.75
Woodlands Road	Polymer	1.83

Performance in wet condition

This aspect is difficult to assess due to the drought conditions in test areas. However, all areas that have been affected by rain have performed very well creating a far safer driving surface with appreciably less loose wet material as shown in the photographs below.

Stabilised road

Untreated road

Environmental

Stabilised pavements are far better environmentally, reducing green house gas emissions and other pollution.

The primary benefits are :

- reduced energy usage due to the decrease in the number of remedial gradings
- reduced cartage of raw materials
- reduced road traffic costs due to improved ride ability, and
- reduced dust emissions, improving living conditions of residents and prevention of the dusting of agriculture.

The Economics of Stabilising

The initial cost of stabilisation is usually higher than a granular overlay. However if the council source gravel pit is not close or the aggregate needs to be purchased from a private quarry then stabilising is comparable or even less costly. A good guide is $17,000 / km for lime or cementitious stabilisation as a comparison to $13,000 / km using a local council pit for a granular overlay.

Historical data from councils with a long history of stabilisation and granular overlays indicate the life of the pavement before reconstruction is 12 years for a stabilised pavement and 8 years for a granular overlay.

The major difference between stabilised and non-stabilised pavements is the frequency of maintenance grading. Fossberg et al (1988) show an optimal grading frequency of 4,000 to 8,000 vehicle passes. This equates to approximately 3 months for a 50 to 100 vehicles per day road. Monitoring of the road condition over the first two years and with corresponding information from councils show a stabilised road only requires an annual grading.

Cost comparison to Granular Overlay

	Stabilised Base	Granular Overlay
Initial cost/km	$17,000	$13,000 (more if long haul)
Life of pavement before replacement	12 years	8 years
Resultant cost pa	$1,400	$1,600
Minor maintenance schedule	Once per year	2 – 3 per year
Cost per maintenance/km *	$1,000	$1,000
Cost pa	$1,000	$2,500
Total cost pa	$2,400	$4,100

* Assumes maintenance crew of grader, 2 rollers and water cart at a cost of $2,500/day. Productivity 2-3 km/day.

Conclusion

The stabilisation of unsealed roads has proved a major improvement in the maintenance of rural pavements.

The maintenance costs are greatly reduced due to a decrease in the requirement for routine grading.

The emission of dust is also reduced and the pavement is less slippery and safer in wet conditions.

The environmental advantages should not be ignored with less energy usage, greenhouse gas emissions and virgin raw materials used.

Author Biography

Greg White is the CEO of AustStab he has over 30 years experience in the design, supply and construction of pavements. During this time he has managed both rigid and flexible pavement operations mainly as a civil contractor or material supplier. Greg has recently joined AustStab with a role to broaden the use of stabilisation as a means of achieving sustainable roads.

Address: Suite 404, 275 Alfred Street, North Sydney NSW 2060

Email address : greg.white@auststab.com.au

Phone number: 0411 445 058

Andrew Middleton has twenty years experience in the stabilisation industry. In this time, during which he has been employed by SPA, he has gained invaluable experience by working through the ranks as an Operator, Foreman, Supervisor and eventually gaining his Engineering qualifications. Andrew has also benefited from overseas work experience in this field in the United Kingdom.

Address: 234 Wisemans Ferry Road Somersby, NSW 2250

Email address: amiddleton@stabilis.com.au