

# The Development of Deep Lift Insitu Recycling Using Slow Setting Additives within the Bega District<sup>1</sup>

by Mal Bilaniwskyj  
Maintenance Planner  
WOLLONGONG ZONE OFFICE, RTA, NSW

## 1 DEEP LIFT INSITU RECYCLING

Recycling of existing pavements by mixing a modified or bonding agent has been and still is being used as a cost effective method of extending road pavement life. Knowledge gained over the past ten years on heavily bound pavements has been in the design and the use of slow setting binders. In the past two years, the introduction of new deep strike rotomill/mixing equipment, the evolution of binder spreaders, the use of heavy earthworks compaction equipment, project management techniques and Quality Assurance have allowed further development of deep lift (300mm to 400mm) insitu recycling of existing pavements to produce heavily bound pavements with a fully extended life. Many of the previous problems, such as under-designed layer thickness, short working times, high initial roughness and extensive cracking appear to have been largely overcome.

Wollongong Zone's Bega and Cooma offices first trialed Deep insitu recycling in March 1993. By 30 June 1994, in excess of sixty kilometres of recycling of the existing natural gravel pavements at depths of between 360mm and 400mm had been completed on State Highway No 1 - Princes Highway, State Highway No 19 - Monaro Highway and a part of State Highway No 4 - Snowy Mountains Highway.

Roughness counts have varied from means of 27 to 43 (apart from one trial length), with standard deviations from 5 to 9 over twenty individual jobs.

A "Q" value of one hundred percent of standard compaction has generally been obtained with a high production in excess of one kilometre per week and with cost savings of between twenty five percent and forty percent on conventional gravel overlays.

Early results from the ALF trial appear to confirm the performance of these pavements, although full results will not be available for some time.

This paper outlines the background leading up to the adoption of this process, the preconstruction requirements that will need to be addressed and some of the key concerns that will need to be overcome.

## 2 BACKGROUND

In late 1992, the Roads and Traffic Authority restructured and Wollongong Division adsorbed Bega Division to become the Wollongong Zone. In the late 1980s and early 1990s, abnormally wet weather had occurred in the Bega District, which resulted in large sections of the Princes Highway, Monaro Highway and parts of the Snowy River Highway failing. Bega District commenced a program of restoration which included some lime stabilisation of the base layer. However, this mainly consisted of gravel overlays with high quality quarry products imported over long distances. The cost of this restoration was up to \$250,000 per kilometre and was relatively slow to construct, taking an average of three to four weeks to complete each kilometre. In late 1992 and early 1993, a project team was established to reassess the work and provide a more cost effective and timely restoration program.

## 3 PAVEMENT INVESTIGATION

Previous pavement information was collated and new pavement investigations were commenced for the worst of the failed sections. The information required was:

1. pavement thickness, quality and moisture
2. the existing subgrade support and capacity to withstand compaction of the layer above
3. presence of rock bars, underground utilities, culverts and

<sup>1</sup> From **Workshop on Pavement Recycling Technology** RTA Technology Development Branch, Canberra, October 1994.

- the extent of asphaltic concrete patches or other non uniform materials.

Test holes to 750mm were initially dug at five hundred metre intervals (down to two hundred and fifty metre intervals if variable pavement existed) and in opposite lanes. Cuttings were augered to a depth of 500mm to determine rock profiles. Deflection testing has been used to determine subgrade support in some cases.

Generally, the majority of pavements consisted of decomposed granite or shale with the quality of the base layers often being of only marginal base quality and more often, only subbase quality or even select. These pavements were moisture sensitive, often having Pls in the range of 6 to 9 and were extensively patched. The materials used for patching ranged from similar natural gravels, high quality DGBs and asphalt, ranging in a depth from 75mm to 200mm. The pavement depths varied extensively and were generally in the range of 250mm to 400mm of cover over the subgrade. Subgrade CBRs were generally low, with the range of 2 to 4 being common and with the moisture content often at or above the field optimum.

#### 4 TREATMENT SELECTION/PAVEMENT DESIGN

Various options for restoration were considered. These included:

- Base quality overlays. These had been carried out previously, however, they proved expensive, were relatively slow and required extensive drying out of the existing pavement layers prior to the overlay, which added to time and cost.
- Lime stabilising of the existing pavements to reduce moisture content and sensitivity, then base quality gravel overlays. These had similar disadvantages to the preceding, with the added risk of permeability reversals, which often occur with "upside down" pavements.
- Lime stabilising the existing layers to modify and reduce moisture content, as well as improving CBRs. This was not viable in the majority of cases, as there was inadequate pavement depth over the subgrades, which would result in limited pavement life.

- Natural gravel overlays were placed to provide cover over subgrade and were then lime stabilised to improve these gravels to base quality. This option was considered to be reasonable, however, a major problem was that the quantity of gravel required for the extensive program was not available. Another problem at the time was the lack of documented data on the long term performance of lime modified pavements.

All of these preceding options were considered to be flexible pavements. Table 1 of "Austroads Pavement Design" shows the relationship between pavement depth, subgrade CBRs and traffic loading. For the typical twenty year design loading of  $5 \times 10^6$  ESAs and subgrade CBR of two to four percent, a pavement depth of 600mm to 700mm was required. This meant that an overlay of between 200mm to 450mm was necessary.

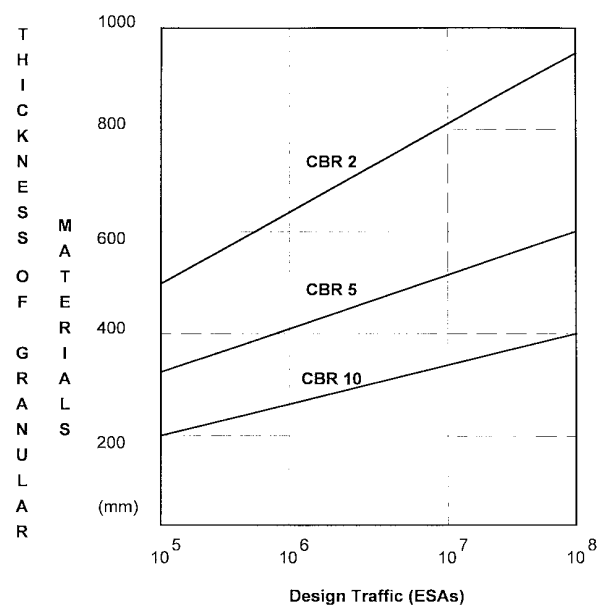


Figure 1

A further option of cementing the existing pavement was considered, with higher dosages of cementitious binder used to produce a fully bound pavement. Table 2 shows the relationship between thickness, subgrade CBRs and traffic loading.

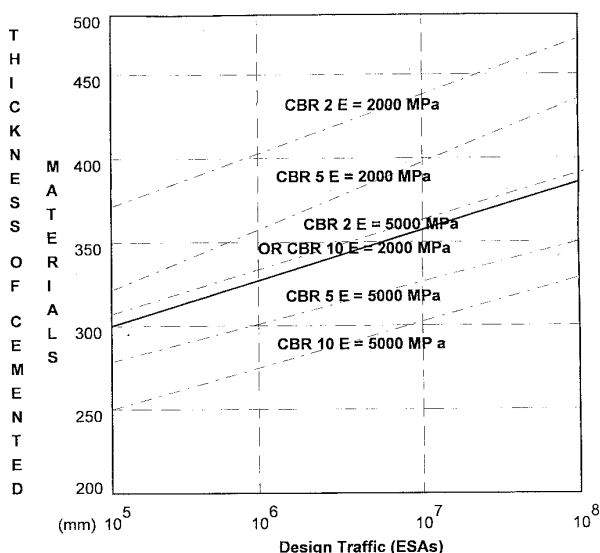


Figure 2

For the typical design loading on this table, a pavement thickness of only 330mm to 340mm is required if a modulus of 5000MPa can be achieved. This is approximately half of that which is required for a flexible pavement and if the existing materials react with the binder, then little to no additional material is required prior to binding. Some of the key elements for bound pavements to work effectively are:

1. *Layer integrity.* If placed in more than one pass, then a bonded interface is essential to avoid premature failure.
2. *Pavement thickness.* As can be seen from Table 2, a variation in thickness of 30mm can vary the life by a factor of ten. Normally for design purposes, an allowance of an additional 25mm to 30mm is made to cover the risk of tolerances in thickness, compaction variability and uniformity of mixing of binder.
3. *Modulus.* A modulus of 2,000 MPa requires approximately an additional 100mm of cover over 5,000 MPa.

Binder application rates of four to five percent have been adopted in Wollongong for new bound pavements (using high quality quarry products), more for control of erosion in the base layer than for strength or modulus. Experience in Wollongong with such pavements has shown that strengths of up to 10 to 12 MPa have been achieved, with moduli in excess of 10,000 MPa, although the norm is closer to 5 to 8 MPa.

Shrinkage cracking is also a consideration but again, experience with pavements in Wollongong has shown that shrinkage is reasonably independent of binder percentage. It is more a function of the amount of plastic fines and the moisture content differential between initial compaction and ultimate field moisture. The rate of setup is important, as early rapid set will increase early tensile strength and thus, will produce greater spacing and greater width of cracks.

A heavily bound pavement option would have a minimum target thickness of 360mm, to risk manage construction variables.

## 5 BINDERS

Experience in Wollongong over the past twenty years and in particular, over the past six years has shown that slow setting additives give similar strengths and moduli as cements, with the additional advantages of longer working time, that is, twelve hours minimum for compaction and wet trim, with final trim to waste within thirty two hours, improved construction tolerances and lower initial roughness counts. Remixing with the addition of a further binder is possible within forty eight hours. Slow setting binders generally used in Wollongong have been:

1. Ground granulated slag/hydrated lime at a 85/15 blend
2. Lime/flyash at a 33/67 blend
3. Lime/ground granulated slag/flyash at a 33/33/33 blend

These additives are suitable for good quality material with a low Pi.

The "common" blends were tested with the top 360mm of pavement layers on two sections of road. One was on the Princes Highway south of Cobargo and another was at the intersection of the Monaro Highway and Snowy Mountains Highway south of Nimmitabel. Testing was carried out at four and six percent additive. Where the Insitu material had a high Pi (a range of 6 to 9), a lime/slag blend at 50/50 was used.

Unconfined compressive strength was determined using seven day accelerated curing tests. This test method was designed for cement based binders and when used with slow setting binders, may give

inconsistent results. The UCS test values are, in Wollongong's experience, less than half that obtained from cores taken from the completed work three to six months later. The results from the seven day accelerated tests on the 50/50 lime/slag blend gave UCS results of around 2 to 4 MPa and the 85/15 blend somewhat lower. This is probably due to the relatively high PI of the material in the base and in the case of the Monaro Highway, the mixing of some subgrade material into the pavement. We can therefore reasonably assume from the Wollongong experience that ultimate strength gains would be at least double these values and that heavily bound pavements will be achieved.

## 6 TRIAL PAVEMENTS

At the time that this option was being considered, the first of the deep strike rotomill/mixers such as the "CMI RS500" were being introduced to Australia. This equipment has the capacity to cut and mix up to 400mm in one or two passes at a high production rate.

In January 1993, it was decided to trial this process. The areas of concern operationally were:

1. The ability to maintain minimum thickness of pavement
2. Accurate spreading and mixing of the binders
3. Ability to achieve one hundred percent standard compaction over the full length of the pavement
4. Ability to achieve low initial roughness counts, that is, lower than fifty counts per kilometre

A Quality Assurance Specification, R38, was produced corporately for this work, however, it was based on cement additives. Wollongong Zone revised this specification to RW38, to allow only slow setting additives.

Two trials, each with a length of approximately five kilometres, commenced in March 1993. One trial was on the Monaro Highway and was carried out by contract which was awarded to Stabilex. The other trial was on the Princes Highway south of Cobargo and was carried out by Bega District Office under Direct Control Project Management and utilising plant hire contracts. Both trials were under full Quality Assurance control.

From these trials, the following conclusions were obtained:

1. Cutting and mixing to 360mm plus was possible with the "RS500" equipment.
2. Two spreading and mixing runs were required, as the five percent additive adopted required thirty nine kilograms per square metre. The "RS500" would create a bow wave if it attempted to mix in all of the additive in one pass.
3. A "Q Value" of one hundred percent standard compaction was achievable as an average of the whole layer depth, however, subgrade support gave variable results between the top and bottom half of the layer. Heavy earthworks vibrating padfoot rollers were used and are required to achieve compaction. Later trials with a "Cat 825" static compactor have also produced excellent results.
4. Roughness counts at Cobargo gave a mean of forty, with a standard deviation of nine. Results from Kellys Corner on the Monaro Highway had a mean of well over fifty, with high counts in the seventies. It is now recognised that Insitu Stabilising by itself will not significantly reinstate shape. However, if shape and roughness improvements are required, then a thin (generally 75mm to 100mm) gravel correction is necessary before the recycling process begins.
5. Twelve hours working time is necessary to achieve satisfactory compaction and wet trimming to fill.
6. Bulking from 360mm to 380mm-400mm occurs after compaction, due to the addition of the binder. Normally the dry trim to waste on the following day removes 10mm to 20mm, which basically balances the effect of bulking.
7. Cores have been progressively taken from these two jobs over the past fifteen months and these have indicated that strength gains have continued linearly with the 50/50 blends over this period of time, with UCS results generally within the 3 to 5 MPa range.

8. Costs have been significantly lower than for previously adopted granular overlays, with direct costs including prime seals at a rate of approximately \$14.00 per square metre. Overheads on any overlay work and minor widening will increase costs to around \$20.00 per square metre.
9. Construction was very rapid and once procedures were refined, rates in excess of one kilometre per week were being achieved.

Based on these results, a further seven kilometres of road were recycled by June 1993 and an additional forty five kilometres of road were completed in 1993/1994.

## 7 SUMMARY

Deep lift insitu recycling has proved to be a cost effective method of recycling the existing pavement to extend its life for future traffic loadings. Costs of between twenty five and forty percent have been saved over conventional gravel overlays and high production with low roughness is achievable.

Twelve hours of working time is required to achieve these results, which essentially limits its use to slow setting binders.

The accompanying paper by my associate, Mr Joe Krsul, will give more details on the current procedures and practices that have been developed and refined operationally in the field and a paper by Mr David Dash, will present the status of the ALF trial currently underway.

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