Category 3: Excellence in Sustainability and Innovation

Improved Design & Construction Methodology for Urban Local Roads in Flood Prone Areas

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Byron Shire Council / Stabilised Pavements of Australia

2024 AustStab Awards of Excellence

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Overview and Objectives

- Byron Shire Council identified River Terrace in Mullumbimby was in need of repair due to the significant degradation observed in the wearing surface which showed signs of being caused by loss of integrity and structural capacity in the base course
- River Terrace is a local road located in the town of Mullumbimby in Northern NSW, which is approximately 20km north west of Byron Bay, both towns are part of Byron Shire Council (BSC).
- River Terrace presented challenges typical to those often faced by local government engineering departments in Australia when considering pavement rehabilitation options including poor material qualities, type and thickness coupled with restrictions on increasing finished surface levels due to flood zoning.
- The objective of the project was to investigate the use of cost and time effective alternative solutions to expensive, slow, wasteful and inconvenient traditional reconstruction methods.

Figure 3: River Terrace Features

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Challenges

- BSC engaged an external consultant to carry pavement investigations and provide a number of possible solutions for the reconstruction of River Terrace, unfortunately council's budgeted funds were unable to support any of the pavement rehabilitation design options nominated.
- River Terrace is located close to Mullumbimby CBD, is a bus route, located adjacent to Mullumbimby creek on one side and light industrial businesses on the other side, a colony of endangered native flying foxes reside in the trees between the road and the adjacent creek.
- The long term annual mean rainfall for nearby Byron Bay is 1735.7mm, not only does Mullumbimby receive rainfall on average almost half of the year (measured by days) River Terrace is classified as a flood zone and is therefore liable to become inundated with moisture when Mullumbimby Creek breaks its banks and floodwaters make their way to the CBD.
- Due to the site being classified as a flood zone increases in height resulting from road pavement resurfacing or reconstruction are not permitted.
- The geotechnical investigation borehole logs indicated there was insufficient existing pavement being sub-standard in quality, variable in nature and thickness to satisfy an initial proposed stabilisation thickness design, described as comprising around 200mm of gravelly silt

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Figure 4: Mullumbimby Fill Exclusion Zone

Figure 5: River Terrace Pavement Condition [2]

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Solution

- BSC engaged another external consultant (SP Design) in August 2023 to provide advice on what other options may be available with a specific reference to in-situ stabilisation (pavement recycling) techniques.
- Discussions between BCS and SP Design revealed that a design solution to incorporate as much of the existing pavement as possible was desired.
- A design subgrade CBR of 4.0% was adopted along with design traffic loading (DESA) of 3.60E+05 for a 20 year design period.
- A design solution incorporating removal of subgrade was deemed not suitable for this site and location, emphasis was therefore placed on not doing any major excavation and attempting to recycle the pavement materials.
- The design solution presented to BSC was a process involving a double stabilisation treatment as follows:-
- 1. Mix lime into the existing pavement and subgrade (ie. Basegrade stabilisation), the intent of this process being to lower the position of top of subgrade to 300mm below the existing surface level without any excavation, all of the existing wearing course to be incorporated into the mix
- 2. A curing period of 3 days minimum was nominated to allow the lime treated materials to ameliorate then the top 50mm of the treated material was to be removed to accommodate placement of the final wearing surface
- 3. Strengthening process would then take place to using a second stabilisation treatment to the design thickness of 200mm to generate a lightly bound base course layer defined as having a UCS in the 1-2mpa range

Figure 10: Pavement Design Cross Sectio

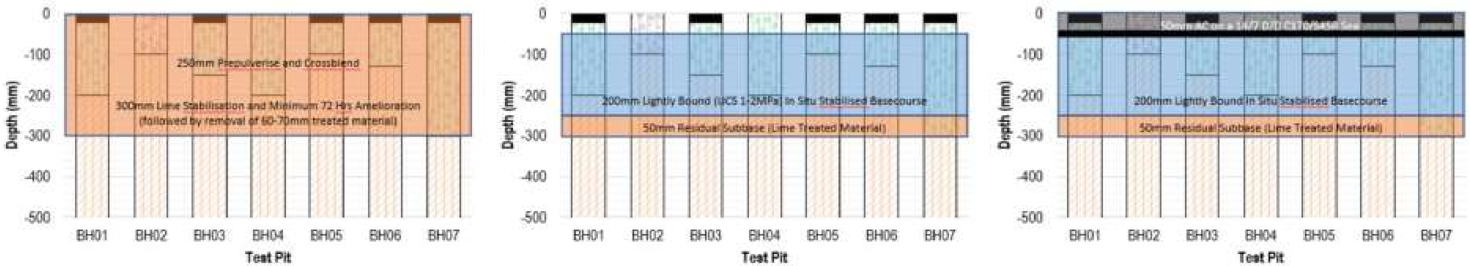

Figure 11: Construction Process [4]

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Stabilisation Mix Design

- Stabilisation mix design trials were designed to replicate the design and construction methodology, design trial methodology as below:
  a) Conduct lime Demand (LD) test on subgrade clay, adopt a lime content of LD + 1% (result LD of 2 +1% therefore 3% lime adopted)
  b) Breakdown all samples together to ensure accurate proportions of the bituminous wearing course, base gravel and subgrade are contained in the mixture to reflect the initial pre-pulversing/crossblending phase
  c) Determine the OMC/MDD relationship of the mixture with LD+1% hydrated lime (3% lime used)
  d) Mix hydrated lime at LD+1% (3% lime used) into the material at OMC, prepare UCS cylinders, cure at 25 degrees for no less than 72 hours (3 days as per planned construction methodology)
  e) Breakdown the lime treated samples to reflect the second stabilisation mixing process then determine OMC/MDD relationship of the mixture with the intended additive of 60/40 slag/lime
  f) Undertake UCS testing with 3%,4% and 5% of 60/40 slag/lime additive, given the target UCS of 1.5mpa an application rate of 4% was adopted (see figure 12 and table 2 below)

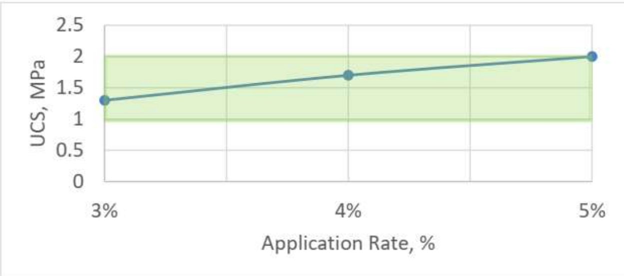

Figure 12: Trial Mix Design UCS Results [5]

Table 2: Adopted Mix Designs [5]

	Application Rate, %	MDD, t/m^3	Field Target Spread Rate, kg/m^2
Hydrated Lime (1st Treatment)	3.0	1.96	18.0
60/40 Slag/Lime (2nd Treatment	4.0	1.94	15.5

Construction

- The intent of the initial construction process requiring the pavement material to be pre-pulverized and crossblended in line with AustStab (2006) was to improve the uniformity of the material to be stabilised so that uniform strength could be achieved.
- Construction Process as below:
- 1. Pre-pulverise and crossblend the existing pavement to a depth of 250mm
- 2. Stabilise the pulverised material with 3% hydrated lime to a depth of 300mm, compact & trim to enable the road to be open to traffic
- 3. Allow the lime treated material to ameliorate for a minimum of 72 hours
- 4. Remove and dispose of 50mm of the lime treated material
- 5. Stabilise the lime treated material 4% of 60/40 slag/lime to a depth of 200mm, trim to 50mm below lip of kerb
- 6. Place sprayed seal SAMI
- 7. Place 50mm AC14 wearing course

Table 3: Construction Timeline

Date	Activity	Duration
10 April 2024	Prepulverisation and crossblending	1 day
12 April 2024	300mm lime stabilisation	1 day
13-15 April 2024	Amelioration	3 days
16 April 2024	Removal of 50mm of lime treated material	1 day
17 April 2024	Slag/Lime strengthening stabilisation	1 day
26 April 2024	Placement of SAMI seal	1 day
30 April 2024	Placement of 50mm AC wearing course	1 day

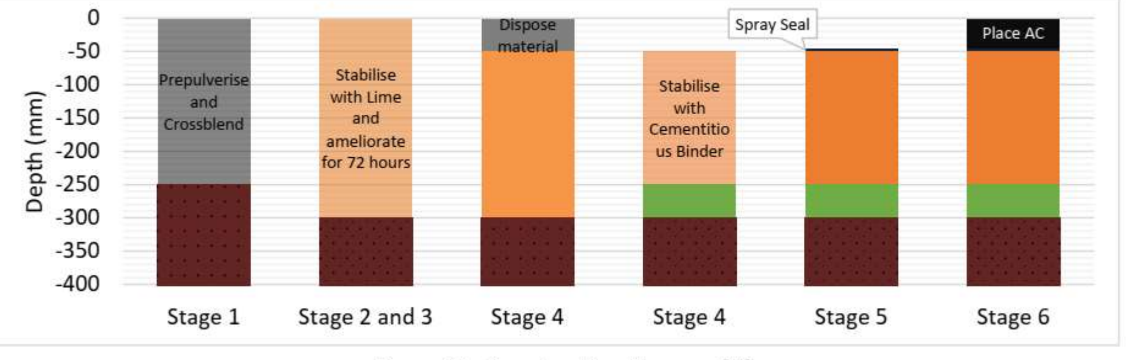

Figure 13: Construction Process [4]

Construction (continued)

- Although the total project time was 21 days only 6 days were required where construction activities took place, 2 isolated small areas of subgrade were also replaced by BSC, one of those resulting from a water damaged service during the recycling process.
- “Low Dust Emission” spreading & mixing techniques were utilised throughout the stabilisation stages of the construction process, this involved placing the stabilsation additive powder on the surface for short controlled distances only in front of the stabilising mixer/recycling machine and having a watercart coupled to the mixer at all times to allow moisture to be added for compaction and for dust control.

Figure 14: Spreading and Mixing Lime

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Figure 17: Mixing 60/40 Slag/Lime

Figure 18: Wet Weather Prior to Sealing

Figure 19: Bitumen Sealing

Post Construction Testing

- There were four approaches to the post construction testing undertaken on River Terrace, these were:
- 1. Density testing
- 2. Unconfined Compressive Strength (UCS) testing
- 3. Clegg hammer testing
- 4. Falling Weight Deflectometer (FWD) testing

The UCS test results were considered unreliable due to a curing regime error

The density testing was performed on samples retrieved from 6 locations, although the density ratios were observed to be favourable the key indicator of success was the low coefficient of variation of the MDD and OMC with both sets of data having a variation of less than 9% indicating material uniformity.

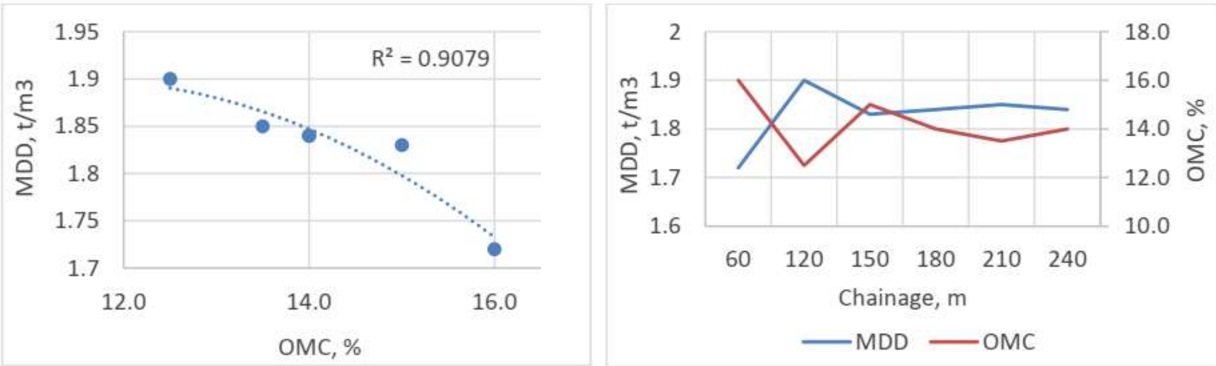

Figure 21: MDD/OMC Post Lime Stabilisation

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The Coefficient variation of the two sets of results from the 17th and 26th was 12% and 10% respectively, the image below (figure24) illustrates how uniform the material appeared from a visual perspective after the slag / lime phase. This was attributed to the initial pre pulverisation phase which considerably improved the uniformity of insitu materials.

Figure 24: Material Uniformity

Figure 25: FWD Testing

Conclusion

- The rehabilitation of River Terrace in Mullumbimby initially presented multiple challenges to Byron Shire Council. These challenges are not unique to this council where restrictions on finished surface levels, flood zoning, thin pavements and limited variable existing pavement structure are encountered.
- A unique solution was successfully implemented involving the double stabilisation strategy which enabled the aforementioned challenges to be overcome by initially improving the non-uniform nature of the existing road through the use of pre-pulverisation and cross blending.
- Secondly the thin pavement challenge was overcome by lowering the position of the subgrade through the first lime stabilisation treatment of the pavement.
- The second stabilisation strengthening treatment was then able to be implemented onto a pavement that had not just uniform materials it also now had adequate depth of cover.
- The reason for the double stabilisation treatment as opposed to a traditional single stabilisation treatment was to position the depth of the subgrade beneath the strengthened base layer and provide additional resistance during exposure to flooding and/or high moisture events.
- The ‘additional resistance’ would be found from having a ‘buffer’ between the subgrade and the strengthened base as well as enabling a higher probability of achieving higher densities in the strengthened base due to being compacted onto a subbase rather than directly onto a subgrade.

Figure 20: Post Asphalt Placement (01 May 2024)

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