QUEENSLAND DEPARTMENT OF MAIN ROADS

REPORT ON

RECONSTRUCTION

OF

WONGLEPONG ROAD

CANUNGRA, QLD

USING

RENOLITH - CEMENT STABILISATION

JANUARY 1999

HUGHES McNAUGHTON CONSULTANTS PTY LTD

Floor 1, 31 Station Road

P.O.Box 276

INDOOROOPILLY QLD 4068

Telephone 07 3378 9111

Facsimile 07 3878 1252

TABLE OF CONTENTS

Page No.

1. PROJECT BRIEF

The Queensland Department of Main Roads (DMR) South Coast-Hinterland District in December 1998, contracted Hughes McNaughton Consultants Pty Ltd to project manage the refurbishment of a section of an existing rural 2 lane unsealed gravel main road. This trial project for the refurbishment of the existing pavement incorporated the use of a Renolith cement stabilised product. DMR requested trialing this type of stabilising agent to study the pavement's performance in minimising the current high maintenance requirements and reducing forecast maintenance costs for other typical sections of roads similar to this section.

The subject road, Wonglepong Road at Canungra in the Gold Coast Hinterland, is a DMR controlled connector road between the highway standard Beaudesert-Nerang Road (Biddaddaba Road) and Mundoolin Connection Road, and is located approximately 3.7 kms north of Canungra. The 750 metre section of road used in the trial was constructed of four different road pavement materials and suffered from high levels of pavement degradation and surface rutting. Most of this section of road is subject to flood inundations from Canungra Creek at irregular intervals and this results in the requirement for more regular reconstruction maintenance and trimming of the running surface.

2. EQUIPMENT AND CONTRACTORS

The local municipal authority in the area, Beaudesert Shire Council was nominated by the DMR as the primary contractor for the construction works and provided all labour, safety personnel and signage, grader, vibrating steel drum and pneumatic tyred rollers and 7650 litre water truck. Stabilised Pavement of Australia Pty Ltd, specialist stabilising subcontractor, based in Somersby NSW, was sub-contracted to provide a CMI RS-650 reclaimer/stabiliser and spreader equipment together with a 24 tonne capacity a rigid body cement spreader and a 18000 litre water truck.

Jimik Investments Pty Ltd supplied 8400 litres of Renolith in 200 litre drums.

3. EXISTING CONDITIONS

This first 650 metre section of Wonglepong Road from the Mundoolin Connection Road to the Canungra Creek bridge crossing consisted of three (3) distinctly different road pavement materials. A fourth different pavement material condition exists on the western approach to the bridge. The entire road surface suffers from severe rutting, corrugations and local failures. The Council had recently regraded the entire length of road as part of their regular maintenance and Photographs 13 & 14 show the loose surface of a section of the existing gravel pavement. Normally this road is highly corrugated.

The first 300 metres from Mundoolin Connection Road was predominantly a sandy lateritic pavement with limited grade along a stunted she-oak ridge. Exposure of the subgrade indicated a section some 50 metres in length which appeared to have been sprayed as part of a previous maintenance minimisation measure with a dust suppression substance (eg sump oil) prior to a pavement being formed. The running surface for the sandy materials was badly corrugated. Verbal reports from the Beaudesert Shire’s maintenance crew on site and local residents indicated this section becomes quickly corrugated normally only one week after the surface has been graded. The sandy nature of the pavement was identified previously by the Council and they had in the past 12 months added a layer of road gravel to the pavement. The gravel was not evident on the surface of the pavement nor to the 200 mm depth of exposed pavement and may have been graded off during subsequent maintenance.

The remainder of this section of the road to the Canungra Creek bridge consisted of approximately 150 metres of an orange highly plastic sandy clay soil pavement with a high fines content where the road graded vertically down to the black soil flood plain. The road pavement in this 200m flood plain section to the bridge was a black clay soil of high plasticity with some pavement gravel mixed. These sections displayed large rutting and severe potholing problems associated with high shrinkage of the clayey nature of the pavement subgrade materials.

The next 100 metre section on the western side of the bridge rose immediately out of the flood plain up a slight hill and appeared to be a well graded orange / brown sandy clay soil with gravel pavement. Due to the grade of the road at this section, rutting and scours in the table drains were common, but potholes and loose surface gravel did not occur until reaching the existing flatter natural clayey gravel pavement above the flood plain (Photographs 13 & 14).

4. EXISTING TRAFFIC

This main road is subject to minimal heavy traffic loadings. The road predominantly services rural properties and turf farms and acts as a connection road to bitumen sealed main roads from the highly populated resort City of the Gold Coast to the rural town of Beaudesert and other towns further west. The majority of heavy vehicles using it are associated with rural farm machinery and light trucks. The use by passenger vehicles is local with some 80-100 vehicle per day recorded during the time of construction works.

5. EXISTING ROAD CROSS SECTION AND DRAINAGE

The standard road cross section for this type of road has a two way cross fall is 6.0m wide with earth to side table drains (refer attached Typical Section). At the approaches to the bridge the cross fall flattens and the width of the road narrows significantly to the 3.6m bridge width. A similar cross section has been maintained as the post construction typical section for comparison of the refurbished pavement. Table drains were trimmed and drainage turnouts cleared as part of normal road maintenance during this construction. The cut depth of table drains was minimal and controlled by cross drainage culverts and road grading.

The present condition of cross culvert drainage is poor. This is due to lack of maintenance of table drains, culverts and insufficient depth to pipe obverts. The first culvert west from the intersection with Mundoolin Road was blocked and did not allow any drainage to pass through. This caused table drain stormwater to pond on the upstream side until it crosses the crown of the road therefore saturating the pavement and causing failures in this area. Cover to the next culvert west was less than 50 mm with part of the pipe obvert exposed and already broken. Additional fill was graded over this culvert during the refurbishment. The remainder of the culverts on the road appear to allow stormwater to pass through to the lower side but all were partially blocked.

Cross drainage was not part of the trial maintenance works, however the above mentioned deficiencies should be repaired as soon as possible to help minimise damage and cost maintenance of the pavement and culverts. The provision of well maintained cross and longitudinal drainage will only enhance the pavement performance and hence the running and wearing surface of the road.

6. TIMING AND WEATHER CONDITIONS

The timing for the construction was just prior to Christmas 1998 in the height of the Queensland summer where the average maximum temperature in Southeast Queensland is 29°C. It is also common to experience severe afternoon storms when the maximum daily temperature exceeds 30°C.

The individual days in question recorded the following weather conditions;

<u>Wednesday, 16 December 1998</u> - Fine, hot humid with a maximum temperature of 32°C at 1pm. Afternoon thunderstorm at 3 pm with approx. 45 mm rain was locally recorded. The temperature dropped to about 24°C.

<u>Thursday, 17 December 1998</u> - Fine, hot and very humid with a maximum recorded temperature of 32°C.

Work commenced at 7.00am on 16 December and was forced to temporarily cease at about 3.15pm due to the thunderstorm, when the road was made suitable for reopening. Further work was achieved after about 40 minutes and concluded for the day at about 5.30pm.

On 17 December, work on the black soil section was commenced at 6.30am, and this section and that on the west side of the Canungra Creek bridge was completed by 1pm. The entire road was then regraded and trimmed and rerolled where necessary under the supervision of the plant and construction supervisor of the Beaudesert Shire Council.

7. CONSTRUCTION METHODS

The pavement was stabilised with a Renolith-cement treatment, utilising the existing road materials to a depth of 200 mm. No additional road base gravel was used. From previous assessment of the plasticity of the clay content of the various existing road material types, it was estimated that an average of 4% cement stabilisation of the pavement materials would be required. Variations to this estimate would be assessed during the construction by engineers experienced in cement stabilisation techniques. The nominal quantities of cement and Renolith used for the various sections of the road is as follows;

Soil Type	Cement %	Renolith (l/m^2)
Sandy lateritic	3	1.2
Sandy clay (orange)	4	1.6
Black clay soils (high PI)	4	1.6
Sandy clay with pavement gravel (orange/brown)	6	2.4

The Renolith usage requirement is obtained from the "Ready Reckoner for Renolith" chart and is directly proportional to the cement usage requirements. The application rate for water indicated on the "Ready Reckoner" is the absolute minimum to be used, but the water requirements for good road construction has to be acknowledged and this is dependent on the temperature of the day, evaporation rates and the materials being used for the construction. In all cases the pavement's optimum moisture content must be achieved and in this project the water usage was quite high (about 4 passes of the water truck) due to the high absorption and mixing rates of the clay / cement mixes and to the temperature of the day.

The application of Renolith for this section of Wonglepong Road was conducted as a trial on a road under regular usage by various vehicle types. Another trial of similarly treated roads was conducted on a heavily trafficked operational road in Thailand in 1997. The Thailand trial was for the reconstruction of an existing road utilising a grader for mixing of pavement material with cement and Renolith and supported by compaction equipment and a considerable hand labour force. This Thai road has produced an all-weather road pavement now sealed which has performed in excess of the owners' expectations.

This current trial was conducted using a mechanical reclaimer/stabiliser. The system for mixing the cement is the same as for normal cement stabilisation, the application of the Renolith product is a major factor for this trial. Through the construction process a simpler and more refined method of application was discussed with the stabiliser operator and as a result variations to this technique should occur for future construction projects. For this trial, the Renolith was sprayed by means of a spray bar attachment from the back of a water truck onto the cement mixed pavement material. This was then mixed by the reclaimer/stabiliser unit prior to a final mix with the reclaimer/stabiliser linked directly to the 18000 litre water truck thereby controlling the water application rate (refer to Photographs 1 to 4 inclusive).

Using the method of application for Renolith described above, the application rate is difficult to control accurately and directly. The application rate could be further regulated by utilising the power unit and speed control of the reclaimer/ stabiliser. Renolith mixed at a constant percentage with water in a water tanker could be directly connected via a flow control valve to the reclaimer/stabiliser. This would allow greater control of the application for this product and would be directly mixed into the pavement without uncontrolled runoff, as occurred on the steeper road grades to the west of the bridge.

8. FINISHED PAVEMENT CONDITION

8.1 Construction

The pavement was reconstructed in four sections in line with the material types and up to 250 metres in length, which was the limit of the cement spreaders' capacity for a 6 metre wide pavement. Once cement, water and Renolith were mixed the pavement material takes on a tacky-sticky feel. This was evident in all materials including the sand pavement material which had a tacky feeling when firmly pressed into the hand. The adhesive property was more noticeable with all materials types "rolling up" and sticking to the grader blade.

The compaction of the pavement was undertaken by a vibrating steel drum and pneumatic rubber tyred rollers. Trimmed surfaces finished smooth, had a glassy appearance on the black clay soil and the sandy clay/gravel soil pavements.

The sandy material pavement refurbishment was commenced first and was being final trimmed at the time of the afternoon thunderstorm storm. Approximately 45 mm of rain fell in 40 minutes. Immediately after the storm this section of pavement was trafficable to all heavy equipment and vehicles. However due to a blocked cross drainage culvert, the upstream table drains and road shoulders became submerged which did not help the compaction process. This saturated pavement subsequently developed soft areas where penetration of the table drain seepage occurred. These areas were remixed the following morning with a further 2 percent cement and Renolith to help remove excess moisture. Following compaction and trimming, this section was reopened to traffic in a complete and finished profile.

Renolith and cement had been mixed into the sandy clay and black soil pavements sections prior to the storm. After the rain no additional water was applied to these sections and the subsequent mixed materials compacted well. It was however late in the afternoon by this stage and the contractor decided to complete rolling and trimming of the black soil section the next morning. After wetting and more compaction the graded finish on these sections of the road was smooth, with the pavement gravel material in the black soil section rising to the surface.

The sandy clay gravel pavement west of the bridge to the end of works was mixed with a higher percentage of Renolith, approximately 2.4l/$m^{2,}$ as previously indicated to allow for some potential runoff during application on the steeper grade. This section compacted very firmly and quickly, and finished with a glassy smooth finish after final trimming.

The reconstruction of the 750 metres length of Wonglepong Road, 6.0 metres wide was completed in 1½ days.

8.2 7 Day Inspection

An inspection of the road was conducted 7 days after completion of construction to assess the impact of road traffic on the various pavement material sections. All sections of the road pavement were performing well with no signs of rutting or corrugations on the sandy section as had occurred previously. The road pavement's various materials perform differently when a comparison between each soil type is made as is shown in the attached photographs 5 to 12 inclusive.

The sandy material is extremely hard with no soft areas and has a smooth finish (Photographs 5 & 6). The orange sandy clay section displays some minor surface cracking which is more evident on the longitudinal graded section when compared to material on flat grades which show minimal or no cracking (Photographs 7 & 8). This is considered possibly to be due to the Renolith application on grade which tended to run off therefore reducing the application rate per square metre to less than designed and also to the higher evaporation rate of water from the sandy clay soils during the hot weather immediately after construction. It was indicated by the Renolith supplier, that the Renolith product would help in binding clayey materials and reduce shrinkage cracks in cement stabilised clay pavements. The surface finish was still smooth with minimal gravel stripping. The black soil pavement has performed well with no evident shrinkage cracking but has some gravel surface stripping (Photographs 9 & 10). The sandy clay soil/gravel pavement has performed very well with only minimal shrinkage cracking noted at the transition to existing gravel pavement. The surface finish is smooth with still a glassy appearance and there is minimal gravel surface stripping (Photographs 11 & 12).

8.3 14 and 28 Days Inspection

An inspection of the road was conducted at 14 days and again at 28 days after completion of the construction. There was very little difference in pavement surface between these two inspection with one exception being the black soil pavement.

Prior to the 28 day inspection, sections of the trial road had been closely graded, retrimmed and watered and Photographs 15 to 20 inclusive indicated the final surface characteristics of the various pavements. The entire length was a hard and smooth running surface.

The sandy pavement material had formed some minor sandy patches up the centre line of the pavement. This was unusual as the remainder of the pavement in this section was extremely hard and had a good wearing finish. It is considered that the centre may have had insufficient compaction at the crown after placing of the cement and Renolith and which was only formed by the grader during trimming as the road was layed in two half sections (Photographs 15 & 16).

The orange sandy clay section of pavement has performed extremely well. There is minor scouring due to water runoff on the surface close to the table drains, however there was no sign of pavement fatigue, shrinkage cracking, rutting or potholing (Photographs 17 & 18). The contractor did not provide any grading or trimming of this section of road.

The sandy clay soil/gravel pavement section west of the bridge has performed extremely well. There are no signs of pavement fatigue, shrinkage cracking, rutting or potholing which is evident in the adjacent untreated section of pavement. The contractor did not provide any grading or trimming of this section of road.

The blacksoil section of pavement when inspected at 14 days displayed minor potholes randomly positioned across the pavement, however the integrity of the pavement appeared to be firm and complete (Photographs 19 & 20). However we have been advised that the contractor has remixed the top 200 millimetres of pavement material, recompacting and grading. This was apparently due to further potholing of the running surface which was not apparent at the 28 day inspection. The supervisor of the Council construction force has indicated that during initial construction, the amount of rain that fell on the afternoon of 16 December had caused the quantity of cement and Renolith applied to be reduced and hence had meant that the pavement was not completed adequately and that they were remixing and recompacting this section only of the pavement. Unfortunately this action which apparently was not referred to the DMR, the supplier of the Renolith nor the supervising engineers will negate any potential residual benefit of the Renolith-cement treated pavement, as was originally placed in this section, for trial and testing purposes.

9. DMR TESTING RESULTS

The DMR undertook testing of the sand and sandy clay / soil pavement materials prior to and following the reconstruction and stabilisation process.

The comparison results to be assessed are basically to compare the properties of the pavement materials initially and after 28 days of placement.

The comparative testing to be undertaken at the discretion of the DMR's testing laboratory personnel may include

- Sieve Analysis
- Atterberg Limits

- AAHSO Standard Density Testing,

and if and where possible,

- Saturated CBR comparisons
- Sample remoulded tensile tests, and
- Unconfined compressive tests.

Currently trial tests are being prepared but at the time of preparing this report no results have been received for the various pavement and soil types from the testing laboratory.

10. RECOMMENDATIONS AND CONCLUSIONS

The results achieved from the trials on the Wonglepong Road in South East Queensland are very similar to those from the reconstruction in Thailand in early 1997.

The sandy soils when stabilised with cement and Renolith produced a very hard running surface which did not furrow nor pothole after the 28 day trial period. This outcome is completely different to the pavement performance prior to the trial.

The orange sandy clay soils have produced an extremely hard, and dense pavement with a glassy wearing surface following trimming. No deterioration of the pavement, surface crazing nor cracking is evident, such as exist on similar road surfaces which have not been stabilised. It would appear that the cement contents used in this trial for both the sandy clay and sandy clay / gravel soil sections was adequate with an additional requirement for both cement and Renolith on any steeper graded sections of road.

It is also evident that drainage plays an important part in all road construction and if this is not operational and adequate, road pavement failures may occur whether stabilisation is undertaken or not. Repairs of the wet and soft areas in the Renolith treated pavement soils caused by the drainage problems were easily undertaken and remedied by remixing of the pavement immediately after application.

The black clay soil section of the road showed some signs of becoming crazed and potholed and it is our opinion that this occurred due to the storm and that inadequate cement and Renolith remained and was available in the pavement mix to hold the soil pavement together and to reduce the potential for shrinkage of these highly plastic soils (PI l 16 to 20). The actions by the Council have negated the ability to obtain results of any testing being undertaken but visual observation of this section of the road shall be maintained and at the 28 day inspection appeared to be of a good condition.

Overall the application of the stabilisation to the pavement materials on Wonglepong Road has been a success.

Lessons learnt and recommendations to be applied in future projects should include;

i. drainage problems should be addressed and corrected prior to reconstruction,

ii. the cement content required for any particular soil should be laboratory tested prior to construction to reduce the plasticity index (PI) of the soil mix to the required level,

iii. the cement and Renolith application rates should be increased where construction is occurring on undulating and hilly terrain due to loss of the mix in the drainage system with the application of water. The amount of increase will be determined by site inspection and will be dependent on the grade of the road, the soil material type and its potential for scouring,

iv. areas under reconstruction when rain occurs should have cement and Renolith reapplied after cessation of rain at a rate of 25% - 40% of the design stabilisation rate previously applied to counter any loss due to run-off or to absorb excess water that may be in the pavement following the occurrence of the rain, and

v. the water content of the pavement shall solely depend on attaining the optimum moisture content of the pavement material for construction and this may depend on pavement soil absorption rates due to temperature and location.

The Renolith product when mixed with cement and stabilised appears to be a most efficient and cost effective product for the upgrading of soil pavement roads, and especially those where a continuous construction output can be achieved. The rate of construction is dependent on only the availability of materials at the site, eg. cement, Renolith and water, and the capabilities of the plant and expertise of the operators of that plant assigned to undertake the roadworks required.

APPENDIX A

PHOTOGRAPHS OF RECONSTRUCTION WORKS

Photo 1 Cement spread over existing pavement material of Wonglepong Road.

Photo 2 CMI RS-650 Reclaimer mixer unit mixing cement and pavement material to a 200mm depth.

Photo 3 Water truck spraying Renolith / water onto mixed cement pavement material.

Photo 4 Final mix of pavement by Reclaimer mixer unit direct fed by water truck prior to compaction.

Photo 5 Renolith - cement treated sand pavement section of Wonglepong Road after 7 days.

Photo 6 Renolith - cement treated sand pavement material.

Photo 7 Renolith - cement treated orange sandy clay pavement section of Wonglepong Road after 7 days.

Photo 8 Renolith - cement treated orange sandy clay pavement material.

Photo 9 Renolith - cement treated black soil pavement section of Wonglepong Road after 7 days.

Photo 10 Renolith - cement treated black soil pavement material.

Photo 11 Renolith - cement treated sandy clay soil / gravel pavement section of Wonglepong Road after 7 days.

Photo 12 Renolith - cement treated sandy clay soil / gravel pavement material.

Photo 13 Wonglepong Road existing pavement after maintenance grading. Note high level of loose gravel on surface.

Photo 14 Loose gravel on surface of existing pavement after maintenance grading.

Photo 15 Renolith - cement treated sand pavement section of Wonglepong Road after 28 days.

Photo 16 Renolith - cement treated sand pavement section of Wonglepong Road after 28 days.

Photo 17 Renolith - cement treated orange sandy clay pavement section of Wonglepong Road after 28 days.

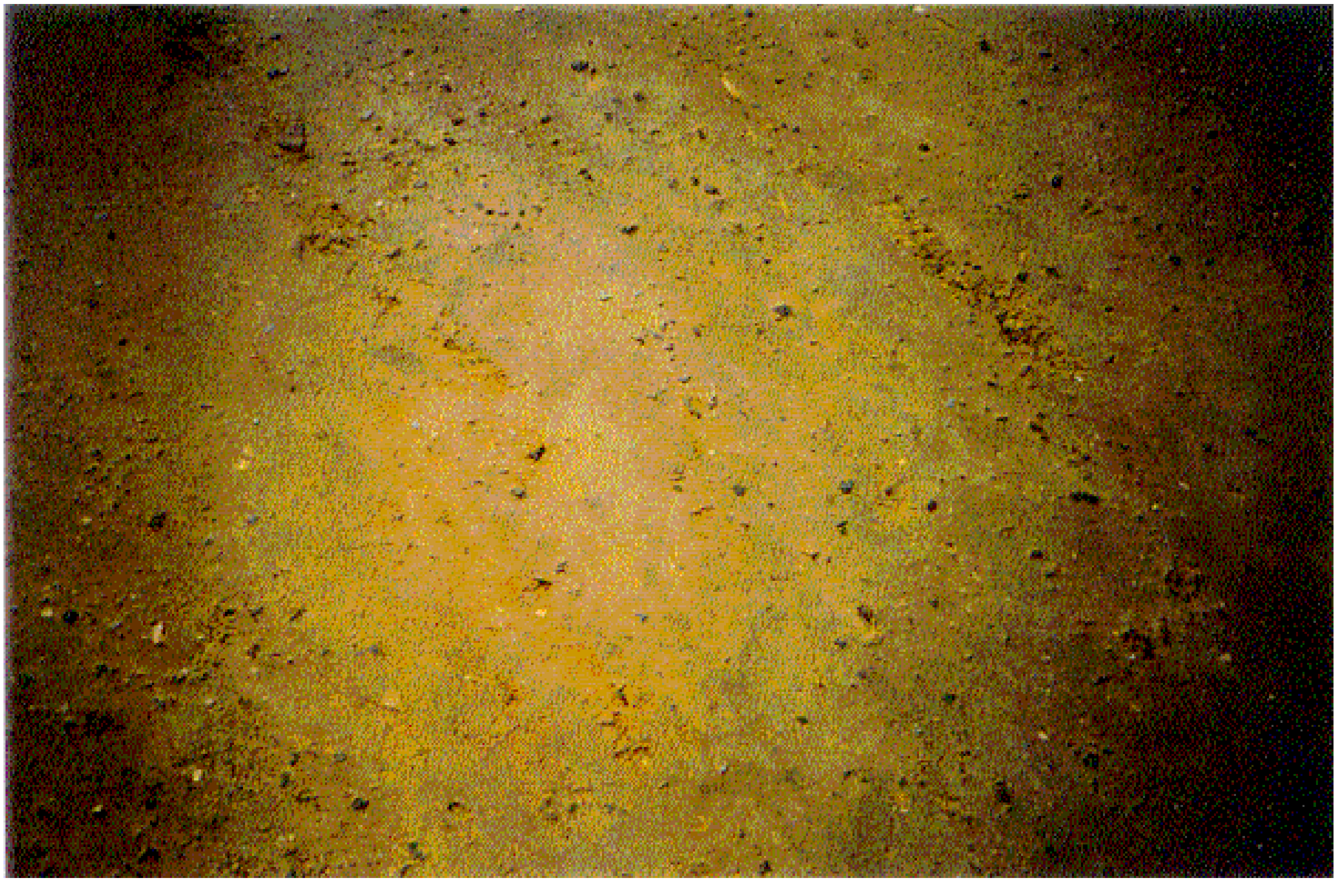


Photo 18 Renolith - cement treated orange sandy clay pavement section of Wonglepong Road after 28 days.

Photo 19 Renolith - cement treated black soil pavement section of Wonglepong Road after 28 days.

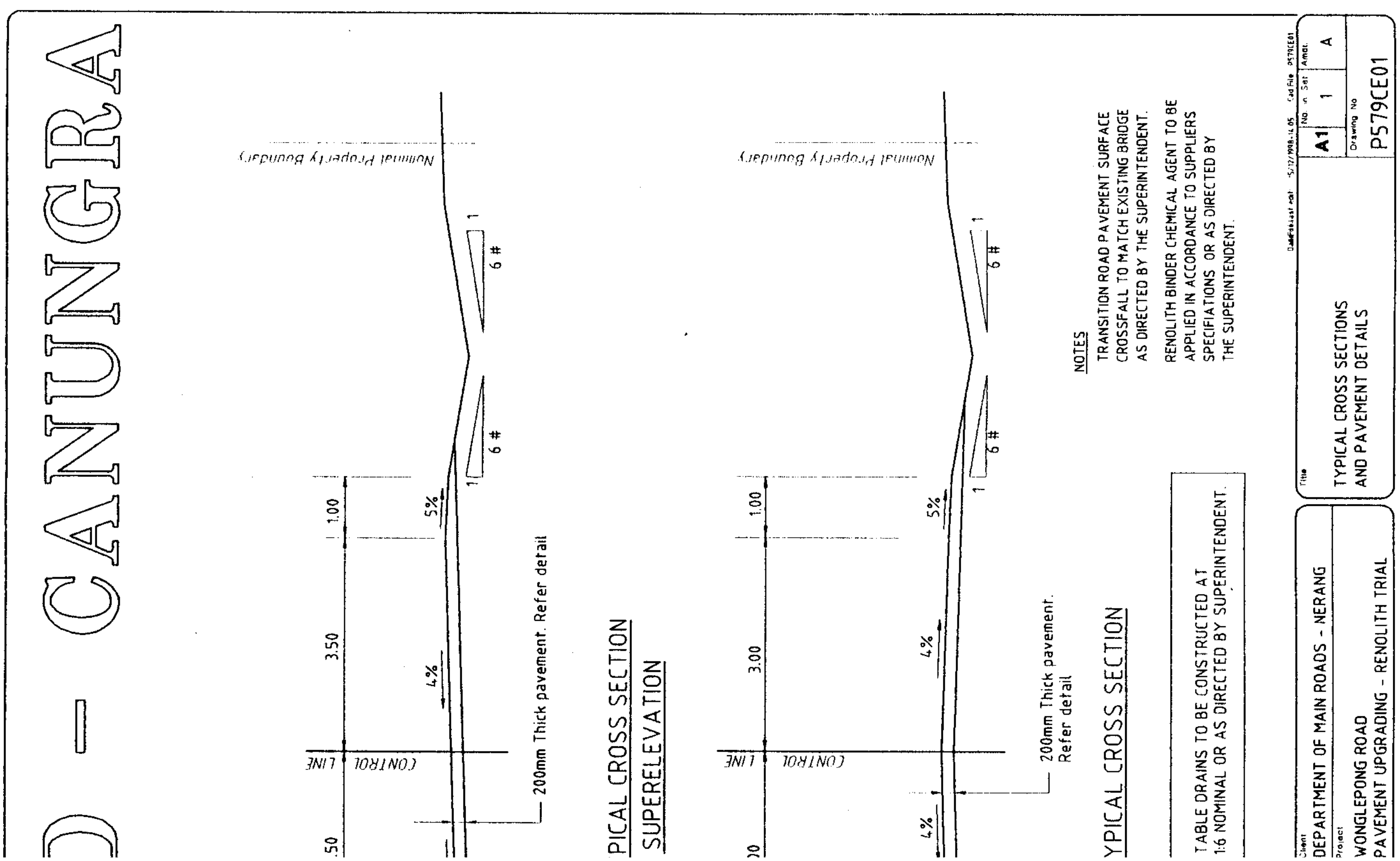
Photo 20 Renolith - cement treated black soil pavement material at bridge approach after 28 days.

APPENDIX B

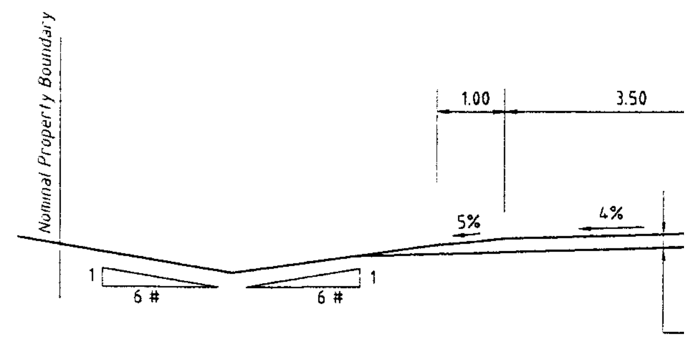
DRAWING P579CE01

TYPICAL CROSS SECTIONS

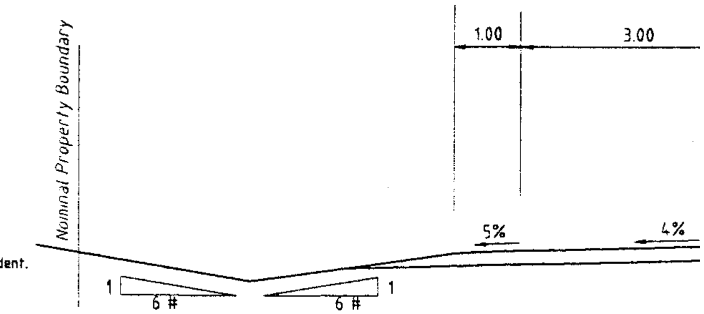
AND PAVEMENT DETAILS



WONGLEPONG ROAD



TYPICA
SUP



TYPIC

#	TABLE 1:6 NOM

NOTES:

1. The contractor is responsible for the the setting out of all works.
2. The contractor is to satisfy himself of the line and level of existing services and is to do all work necessary to protect same from damage.
3. All new work is to join smoothly to existing.
4. Pavement depths are subject to confirmation by the Engineer.
5. Table drains are to be turned out as directed on site.
6. DRAWING NOT TO SCALE.

200mm (Nominal) Cement Treated Gravel Pavement
4% Cement (16kg/m^2)
Renolith Chemical Binder (1.66L/m^2)

Note: Pavement depth, application rates of Cement and Renolith to be confirmed onsite by the Superintendent.

PAVEMENT DETAIL

WONGLEPONG ROAD

DRAWING LIST

DRG. NO.	TITLE
P579CE01	TYPICAL CROSS SECTIONS AND PAVEMENT DETAILS

No.	Date	App'd	Amendment
A	12/98	PH	For Construction

HUGHES McNAUGHTON CONSULTANTS PTY LTD
PROJECT MANAGERS & CONSULTING ENGINEERS ACN 010 172 295
ACEA
• Brisbane 31 Station Rd Indooroopilly Q 4068 Tel (07) 3378 9111 Fax (07) 3878 1252
○ Sydney 47a Penrose St Lane Cove NSW 2066 (02) 418 7866 (02) 418 5265

Designed	Drawn	Client
P.H.	M.O.	DEPART
Checked M.S.D.	15/12/98	Project WONGLE
Approved P.R.H.	15/12/98	PAVEME