Department of Public Works and Highways, Philippines

PROJECT REPORT PR/INT/281/04

Construction report: stabilized sub-bases, Bauan/Balayong trials, Philippines

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PREFACE

This report forms one of the deliverables from the DFID funded project on Stabilized Sub-bases for Heavily Trafficked Roads which is being undertaken as part of a co-operative research programme with the Bureau of Research and Standards, DPWH, Philippines. It also forms one of the deliverables under Project 3 within the overall Pavement Investigation Research project which is being undertaken with DPWH with the support of the Asian Development Bank.

The purpose of this component of the co-operative research project is:

> *To extend the service lives of flexible and rigid pavements by increasing the use of appropriate pavement design methods and material specifications.*

The objective of Project 3 is

> *To develop methods of using the indigenous marginal materials in the Philippines so that they can be used with confidence for road construction and other civil engineering purposes.*

Under the pavement investigation research, project 3 is divided into two parts namely:' the use of marginal materials for road construction' (project 3.1) and project 3.2,' developing stabilised sub-base specifications for both flexible and rigid road pavements in the Philippines'.

The cost of road construction and associated environmental degradation can be greatly reduced if locally available materials, found near the road alignment, can be used in construction, thereby reducing the extraction and haulage of expensive high quality aggregates. Such materials may often be of marginal engineering quality in terms of standard specifications but, by modification and/or suitable design and construction methods, their use can be very cost effective. The methodology of the research is based on successful previous research on indigenous marginal materials in other countries.

Use of stabilized sub-bases for heavily trafficked using materials of either marginal quality (originally) or better quality materials can effectively counter: poor materials availability or selection; poor construction control; poor drainage and the general effects of the ingress of water. Used with unbound road bases in flexible pavements it can also prevent or reduce reflection cracking in the upper layers of the pavement and improve the overall service life of the pavement.

This report is one of 26 which are being delivered under this part of the pavement investigation research project. These reports are:

No	Title	Report code	Type
1	Identifying and mapping marginal materials in the Philippines		Project report
2	Distribution of gravel-sized and fine particulate materials from Mount Pinatubo, Philippines	PR/OSC/172/99	Project report
3	Outline design for pilot scale trial on the Zambales coastal road		Project report
4	Making good use of volcanic ash in the Philippines.	PA 3594/00	Conf. paper

5	The use of volcanic ash in bituminous mixes	PR/OSC/138/98	Project report
6	A study of the volcanic ash originating from Mount Pinatubo, Philippines	PR/INT/194/01	Project report
7	Investigation into the use of Lahar as fine aggregate in hot rolled asphalt and asphaltic concrete wearing courses	PR/INT/220/01	Project report
8	Specifications and guidance for construction: Pilot trials on the Nasugbu to Batangas City Road, Batangas Province: Lahar Asphaltic Concrete and Hot Rolled Asphalt (Station 96+665 to 96+994)		Project report
9	Outline design for pilot scale trials using weathered volcanic rock and soft limestone on the Malicboy to Macalelon road in Quezon Province.		Project report
10	Specifications and guidance for construction: Pilot trials on the Malicboy to Macalelon road, Quezon Province; site Agdangan		Project report
11	Agency estimate for a pilot trial on the Malicboy to Macalelon road, Quezon Province; site Agdangan		Project report
12	Construction report: Pilot trials on the Nasugbu to Batangas City Road, Batangas Province: Lahar Asphaltic Concrete and Hot Rolled Asphalt (Station 96+665 to 96+994)	PR/INT/273/03	Project report
13	Construction report: soft limestones and weathered volcanics as roadbases trial (Agdangan)		Project report
14	Performance of volcanic ash in bituminous mixes	PR/INT/282/04	Project report
15	Performance of marginal materials in roadbases: Soft limestones and weathered volcanics		Project report
16	Specification for using lahar and volcanic ash in bituminous mixes		Project report
17	Specifications for the use soft limestone		Project report
18	Specification on the use of weathered volcanics		Project report

PROJECT 3.2

19	Outline design for a pilot scale trial on the Nasugbu to Batangas City road.		Project report
20	Literature review: Stabilised sub-bases for heavily trafficked roads	PR/INT/202/00	Project report
21	Specifications and guidance for construction: Pilot trials on the Nasugbu to Batangas City Road, Batangas Province: Site B, Mabini Junction (Station 142+340 to 142 + 700)		Project report
22	Specifications and guidance for construction: Pilot trials on the Nasugbu to Batangas City Road, Batangas Province: Site A, Santa Teresita pilot trial (Station 135+450 to 135+610)		Project report
23	Construction report: stabilised sub-bases (Bauan/Balayong and Sta. Teresita trials)	PR/INT/281/04	Project report
24	Performance report: stabilised sub-bases (Bauan/Balayong and Sta Teresita trials)		Project report
25	Final report		Final report
26	Guidelines on Stabilised Sub-bases		Project report

CONSTRUCTION REPORT: BALAYONG/BAUAN PILOT TRIAL STATION 142+340 TO 142+700

CONTENTS

Note that Appendices B, C, D, E, F, G, H, I, J, K, L and M are not included in this version of the construction report.

CONSTRUCTION REPORT: BALAYONG/BAUAN PILOT TRIAL STATION 142+340 TO 142+700

1 INTRODUCTION

The pilot trial described in this document forms part of the Pavement Investigation Research Project (PIR) which is being carried out under the Sixth Road Project (SRP), ADB Loan No. 1473-PHI. The overall objective of the PIR is to implement a programme of research aimed at improving the performance of road pavements in the Philippines, through a better understanding of the available materials and the transport demands, and the adaptation of modern techniques to the Philippine climate and traffic.

The pilot trial described herein forms part of sub-project 3-2 which addresses the use of stabilized sub-bases for heavily trafficked roads. This is one of two pilot trials that have been constructed to investigate the performance of stabilized sub-bases with respect to their technical suitability and cost. The trial is located on the SRP project LZH-D; the structural overlay of the Nasugbu- Palico-Batangas City road. A location map is shown in Plate 1.

Further information is given in the description of the works.

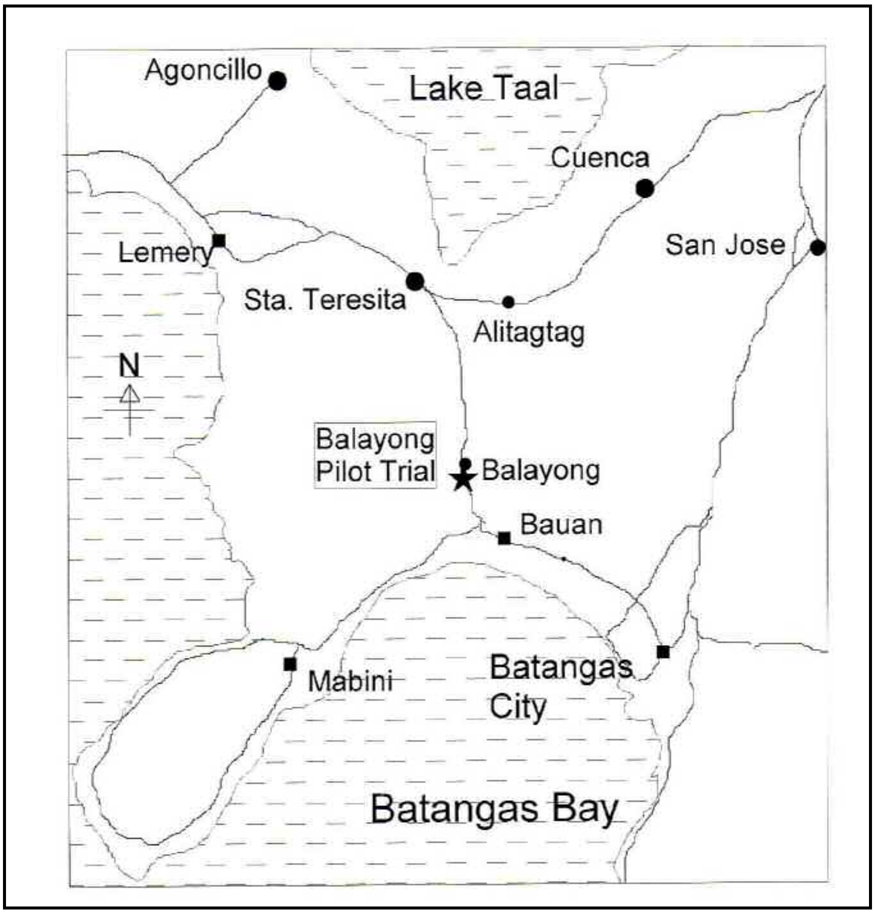


Plate 1 Location of Balayong trial, Batangas Province

2 DESCRIPTION AND PROGRAMME OF WORKS

2.1 Trial sections

The trial comprises four sections on the left-hand side of the road. The right-hand side makes a fifth section. A description of the principal works for each section is given in Table 2.1.

Table 2.1 Experimental sections and principal activities

Section	Lane	Description of experiment	Station, Km		Length m	Principal activities
			from	to		
1	Left	Control section	142+340	142+440	100	AC surfacing and Granular roadbase over an imported granular sub-base
2	Left	Stabilized sub-base (3MPa)	142+440	142+520	80	AC surfacing and Granular roadbase over a stabilized sub-base (3MPa) of varying thickness
3	Left	Stabilized sub-base (5MPa)	142+520	142+620	80	AC surfacing and Granular roadbase over a stabilized sub-base (5MPa) of varying thickness
4	Left	Stabilized sub-base (1MPa)	142+620	142+700	100	AC surfacing and Granular roadbase over a stabilized sub-base (1MPa) of varying thickness
5	Right	Standard works	142+340	142+700	360	AC surfacing over a cement stabilized base and existing granular sub-base

2.2 Pavement design

The designed subgrade CBR was 5 per cent. The design cumulative traffic loading is 10million ESAL'S over a period of 10 years. The pavement thicknesses comprise: an asphalt concrete surfacing of 100mm; a roadbase of 200mm; and a sub-base which varies between 200 and 350 mm in the three experimental sections, Sections 2 to 4, but has a constant thickness of 350mm in the control section, Section 1. The quality of materials for the surfacing, and the roadbase meet or exceeded (by design) those required in the DPWH Standard Specifications for these layers. The unbound layer used for the sub-base in the control section was also determined to exceed, by design, Standard Specifications by increasing the CBR requirement from 25 to 30%. The sub-bases of the remaining three sections, the experimental sections, were designed to have comparatively differing strengths and stiffness. The experimental layout can be seen in the longitudinal section of the trial given in the drawings (see Appendix A).

2.3 Drawings

The straight-line diagram of the trial, longitudinal section and the typical cross-sections are given in Appendix A.

The stabilized sub-base trial sections have only been constructed in the westbound lane with necessary expansion into the eastbound lane of the road of approximately 0.6 metres. The design allowed for benching for the placement of layers. However the Contractor cut vertically at the 0.6m offset from the centre-line for the full depth of the construction. The right-hand side of the road was rehabilitated in accordance with the requirement s set out in the specifications for the main civil works project LZH-D.

For the westbound lane, the works involved the complete removal of the existing asphalt concrete surfacing and existing cement treated base. Thereafter, the sub-base was excavated and stockpiled. In three sections, it was processed with cement and replaced. In the fourth section, it was replaced with an aggregate sub-base. Excavation below the sub-base continued for approximately 0 to 120mm to remove a layer of imported aggregate and an old thin asphalt concrete surfacing to expose the natural subgrade. These works extended across the road shoulders to the side-slope. Material excavated from under the shoulders was stockpiled as sub-base, or subgrade as appropriate for its type. Excavated natural subgrade was reused to make up the required levels to the bottom of sub-base. It should be noted that in three experimental sections, the subgrade level was varied to accommodate a varying thickness of stabilized sub-base.

After preparation of the subgrade, either an aggregate sub-base (Section 1) of constant thickness or a stabilized sub-base (three sections each with differing strengths) and varying thickness was laid. A well-graded crushed stone base course was laid at constant thickness throughout each of the trial sections. This was followed by an asphalt concrete surfacing which was placed in two layers, each of equal thickness.

For the eastbound lane, as mentioned above, the repairs and replacement of materials were substantially the same as those being carried out under Contract LZH-D, although they were more extensive than planned under the original Contract. For example, the asphalt concrete surfacing and the cement treated base (CTB) were replaced entirely.

Drainage works were carried out throughout the length of the trial, and on both sides of the road by providing grouted rip-rap side drains. This was essential because of the elevations at the site and because of the use of a permeable road-base.

The programme of works is given in Appendix B. The dates for each of the construction items of work carried out in the left lane are given in Table 2.2. Those for the right lane are given in Appendix B.

Table 2.2 Construction dates for the left lane

Item	Stationing (Km)		Length	Section	Layer	Laying dates	
	from	to	m			Day	Date
105	142.340	142.440	100	1	1	Fri	12-Apr-02
105	142.440	142.520	80	2	1	Fri	26-Apr-02
105	142.520	142.600	80	3	1	Thu	16-May-02
105	142.600	142.660	60	4	1	Fri	24-May-02
105	142.660	142.700	40	4	1	Fri	14-Jun-02
200	142.340	142.440	100	1	1	Mon	15-Apr-02
200	142.340	142.440	100	1	2	Wed	17-Apr-02
200(2a)	142.440	142.520	80	2	1	Tue	30-Apr-02
200(2a)	142.440	142.520	80	2	2	Tue	07-May-02
200(3a)	142.520	142.600	80	3	1	Fri	17-May-02
200(3a)	142.520	142.600	80	3	2	Sat	18-May-02
200(1a)	142.600	142.660	60	4	1	Tue	28-May-02
200(1a)	142.600	142.660	60	4	2	Tue	28-May-02
200(1a)	142.660	142.700	40	4	1	Tue	18-Jun-02
200(1a)	142.660	142.700	40	4	2	Tue	18-Jun-02
202a	142.340	142.374	34	1	1	Fri	03-May-02
202a	142.374	142.440	66	1	1	Tue	07-May-02
202a	142.440	142.520	80	2	1	Thu	09-May-02
202a	142.520	142.600	80	3	1	Tue	21-May-02
202a	142.600	142.660	60	4	1	Tue	06-Jun-02
202a	142.660	142.700	40	4	1	Wed	19-Jun-02
301	142.340	142.440	100	1	1	Thu	09-May-02
301	142.440	142.520	80	2	1	Wed	08-May-02
301	142.520	142.600	80	3	1	Wed	22-May-02
301	142.600	142.660	60	4	1	Thu	30-May-02
301	142.660	142.700	40	4	1	Thu	20-Jun-02
302	142.340	142.520	180	1&2	1	Fri	10-May-02
302	142.520	142.600	80	3	1	Thu	23-May-02
302	142.600	142.660	60	4	1	Fri	00-Jan-00
302	142.660	142.700	40	4	1		
302	142.600	142.700	100	4	1	Fri	07-Jun-02
310B	142.340	142.520	180	1&2	1	Fri	10-May-02
310B	142.520	142.600	80	3	1	Thu	23-May-02
310B	142.600	142.660	60	4	1	Thu	06-Jun-02
310B	142.340	142.700	360	1,2,3&4	2		
SPL-3	142.340	142.600	260	0	1	Sat	20-Apr-02

3 CONSTRUCTION

As was recommended in the specifications for the works the permanent works began in the westbound lane from station 142+340 towards station 142+700. This was to provide a stockpile of available sub-base material in advance of further works in the westbound lane. Works were only opened in the eastbound lane after they were considerably advanced in the westbound lane. A summary table of requirements is provided in Appendix D.

3.2 Road levels

In the design the final road levels were required to remain the same as the existing levels. During the works some reductions in level were permitted in the right lane (eastbound) to improve the longitudinal alignment of the road through the trial section.

As is usual, the Contractor was required to work to accurate elevations during both the excavation and placement operations. A permanent benchmark was established and levels were set out at 10m intervals longitudinally along the road. Important levels for the purposes of the experimental design were those for the top of subgrade, top of sub-base and top of roadbase. These were determined, and pegged for measurement at 0.5m intervals transverse to the road on both sides, extending from the centre-line to the outer edges of the shoulders. The “Dipping method ” from string lines drawn tight across the pegs, was used to determine the thickness of each layer of construction. The data are given in Appendix E.

3.3 Public accessibility

The Contractor was required to maintain public accessibility to the roadside facilities, residential houses and businesses. This necessitated maintaining access to a local road near station 142.660 on the left side and a facility at 142.360 on the right side. The requirements on the left side at 142.660 also involved relocating a major water pipe which crossed the road near that location. The existing level of the pipe was at the top of sub-base level and it was relocated to a level near the top of the subgrade. This necessitated Section 4 being constructed in two sub-sections, the first 60 metres followed by the remaining 40 metres.

3.4 Raw Materials used for construction

A list of the raw materials used in the construction and the suppliers is given in Table 3.1 together with the construction Item for which they were being considered. A summary of the properties is given in Table 3.2 and the test reports are given in Appendix F.

Table 3.1 Raw material types and suppliers

Material	Type	Supplier	Considered for Item:
Cut-back asphalt	MC 70	Shell Pilipinas Petroleum Corp	Prime coat
Emulsified asphalt	SS-1h	Shell Pilipinas Petroleum Corp	Tack coat
Asphalt cement	60-70	Shell Pilipinas Petroleum Corp	Asphalt concrete
Hydrated lime		Oria Agrotech. Rosales, Pangasinan	Mineral Filler
Crushed aggregate	G1	Rockworks Inc. Taysan, Batangas	CTB / Unbound Sub-base
Crushed aggregate	3/4	Rockworks Inc. Taysan, Batangas	CTB
Crushed aggregate	3/8	Rockworks Inc. Taysan, Batangas	Unbound Sub-base
Manufactured sand	S1	Rockworks Inc. Taysan, Batangas	CTB
Natural sand		Double B Construction, Agoncillo, Batangas	CTB
Crushed Aggregate	3/4	Concrete Aggregates Corp. (CAC), Angono, Rizal	Base Course
Manufactured sand	S1	Concrete Aggregates Corp. (CAC), Angono, Rizal	Base Course
Manufactured sand	S1	Robust Arjin, Mariveles, Bataan	Base course
Crushed Aggregate	G1, 3/4, and 3/8	Robust Arjin, Mariveles, Bataan	Base course
Cement	Portland Type 1	Fortune Cement Inc.	CTB
Cement	Portland Type 1	Dragon Cement Inc.	Stabilized sub-bases
Fine soil	Binder	E.C De Luna (Contractor) from Banilad	Unbound sub-base

Table 3.2 Properties of the raw aggregates

Identification		Particle size distribution: Percentage passing (Imperial/metric units, mm)																	Plastic.	Aggregate Properties									
																				Sand	Unit weight		SG	Abs.	Abr.	SSS	Fract.	Flake.	Elong.
Supplier	Type	Max	2.00	1.50	1.10	1.00	3/4	1/2	3/8	#4	#8	#10	#16	#30	#40	#50	#100	#200		Equiv.	Loose	Rodded	Oven		loss		faces	Index	Index
		size	50.0	37.5	28.0	25.0	19.0	12.5	9.5	4.75	2.36	2.00	1.18	0.60	0.48	0.30	0.15	0.08	PI	%	kg/m^3	kg/m^3	dry	%	%	%	%	%	%
CAC	S1	10.0							100.0	94.8	60.1		33.2	19.3		8.8		2.6	NP	96	1604	1869	2.702	1.5	NA	5.4	NA	NA	NA
CAC	3/4	25.0				100.0	95.1	55.6	28.8	4.3	2.3		1.9	1.3		0.9		0.5	NP		1694	1857	2.775	0.9	19.0	1.3	100	21	17
Robust	S1	10.0							100.0	95.5	69.9		57.1	35.4		26.0	15.9	6.3											
Robust	S1	10.0							100.0	96.7	64.2		49.0	37.8		25.1	17.9	6.2	NP	94	1598	1845	2.710	1.8	NA	5.0	NA	NA	NA
Robust	3/8	12.5						100.0	76.8	32.6	14.0		11.0	9.7		7.9		5.3											
Robust	3/8	12.5						100.0	96.3	28.4	12.0	7.8			6.1		5.9	2.3	NP		1600	1713	2.724	0.9	23.1	1.3	100	27	16
Robust	3/4	25.0				100.0	96.8	55.4	29.1	6.8	4.1		3.4	2.0				1.0											
Robust	3/4	25.0				100.0	95.8	51.8	28.1	4.0	4.0		4.0	4.0		4.0		1.8	NP		1592	1679	2.774	0.9	21.8	1.2	100	24	15
Robust	G1	50.0	100.0	98.0	98.0	70.8	30.3	5.9	3.2			2.6			1.2			1.0	NP		1586	1734	2.801	0.7	18.8	1.2	100	25	15
Rockworks	S1	10.0							100.0	93.5	36.8		24.8	19.5	17.5	15.3	14.1	12.8	NP	90	1410	1650	2.603	2.0	NA	7.2	NA	NA	NA
Rockworks	S1	10.0							100.0	99.4		51.7			20.5			10.4					2.513	3.3		7.5			
Rockworks	3/8	12.5						100.0	99.7	33.1		6.5	5.9		5.2		4.7	3.6	NP		1388	1469	2.524	3.0	27.9	6.9	100		
Rockworks	3/8	12.5						100.0	96.7	5.2		0.7			0.5			0.3					2.618	2.9		7.2			
Rockworks	3/4	25.0				100.0	86.5	20.1	10.1	2.9		1.0			0.7			0.6	NP		1410	1550	2.680	1.6	26.6	5.4	100	14	18
Rockworks	3/4	20.0				100.0	85.4	12.7	3.2	1.0		0.8			0.6			0.5					2.721	2.1					
Rockworks	G1	37.5		100.0	100.0	35.4	2.5	0.6	0.5			0.5			0.2			0.2	NP		1420	1610	2.690	1.4	24.4	5.8	100	16	19
Rockworks	G1	50.0	100.0	97.5		28.8	1.7	0.3		0.1		0.1			0.1			0.0					2.737	1.3		6.0			
Double B	Agoncillo Nat.sand	10.0							100.0	90.2	82.4		68.2	54.3	37.2	24.8	20.5	16.1	NP	79	1384	1642	2.496	2.7	NA	8.2	NA	NA	NA
Agrotech	Lime																100.0	97.3	NP				2.467						
	Cement																		NP				3.150						

3.5 Construction of the westbound traffic lane; (to Nasugbu)

Item SPL-1 Temporary diversion road

The right-hand lane (eastbound) was widened temporarily to facilitate the movement of public vehicles whilst work was being carried out on the westbound lane. This was carried out by placing additional shoulder material (Item 300) to adjust the level of the shoulder, and make it more suitable for vehicular traffic. Periodic dampening with water sprayed onto the surface was carried out to reduce dust. The deviation extended for at least the length of the open works on the westbound lane plus a suitable length for safe manoeuvring of traffic. Provision was made in the Programme of Works for a diversion along the entire length of the pilot trial.

The minimum trial working length was 90m or one experimental section, whichever was the longest. At the request of the Contractor this length was shortened where necessary in consideration of the passage of public traffic.

3.5.1 Excavations and removals

Item 101(3a) Removal of existing asphalt concrete

The existing asphalt concrete within the trial section was broken out and removed to waste in accordance with the procedures established for the Contract LZH-D.

Item 102(2a) Excavation of existing cement treated base course

Thereafter, the existing CTB was excavated throughout the westbound traffic lane of the trial section, length by length. The works were extended by a distance of 0.6 metres from the centre-line into the eastbound lane.

Item 102(4a) Excavation of existing sub-base including hauling

The existing sub-base material from under the traffic lane and shoulder was excavated and was stockpiled locally (initially) for reuse in the works as stabilized sub-base. For this the Contractor obtained access to a large area of open ground adjacent to the road on the north side. The material was differentiated from any subgrade or other material, which was stockpiled separately.

After initially storing the existing sub-base material at the site, it was loaded and transported to the Contractor's materials batching yard near Banilad where it was again stockpiled in preparation for processing with cement. A CTB plant was used to mix the materials with cement, as described under Items 200 (2a, 3a and 4a).

Item 101(5a) Excavation of existing imported subgrade

The existing imported subgrade (found below the excavated sub-base) was excavated from under the traffic lane and the shoulder to expose the natural subgrade. The imported material, a granular material containing stone, frequently included the remains of an old asphalt concrete layer. In the test pits dug during the design phase, and in practice during construction excavations, these layers had a combined thickness of up to 120mm.

Any natural subgrade material found under the shoulders above the required top of subgrade level was excavated and stockpiled separately, as necessary.

3.5.2 Construction of the subgrade

Item 105 Subgrade preparation

The stockpiled natural subgrade material was blended with additional material won from deep excavations from the ditch on the left-hand side, and was then mixed with the top of the exposed subgrade material and used to fill in to the bottom of sub-base level under the pavement. The blend was approximately 2:1ditch material to existing subgrade material. Mixing was carried out to attain a uniform subgrade material. The properties of the blended material are given in Table 3.3 and the grading is given in Figure 3.1. The engineering test reports are given in Appendix G.

Table 3.3 Properties of the blended subgrade

Property	Unit	Result
Liquid Limit	%	50
Plastic Limit	%	30
Plasticity Index	%	20
Per cent passing 75µm	%	74.4
Type Class		A-7-5
Maximum Dry Density (T180)	Mg/m^3	1.48
Optimum Moisture Content	%	22
CBR at 95% of MDD	%	8

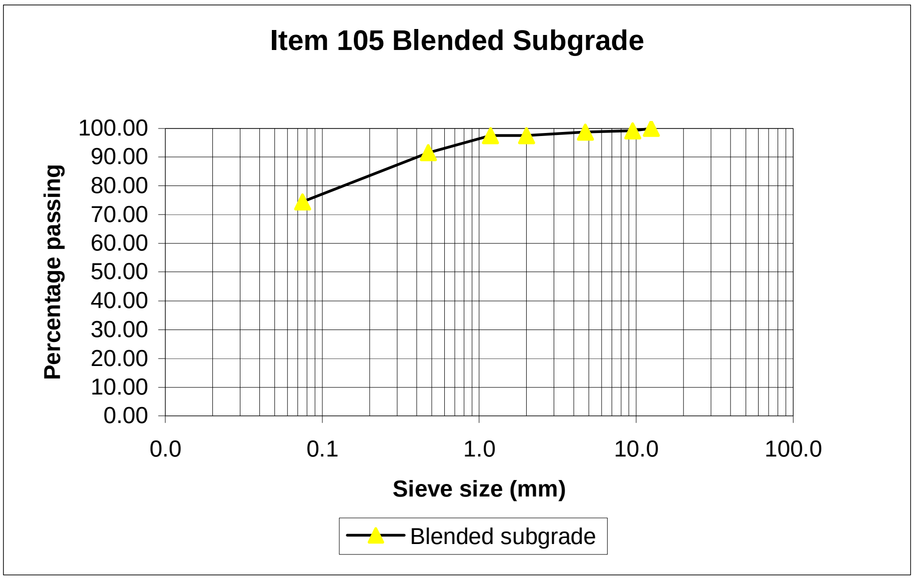


Figure 3.1 Grading of the blended subgrade material

Suitable layer thicknesses for compaction were used. Due attention was paid to the varying design thicknesses of the stabilized sub-base material, where appropriate. These varied from 200 mm to 350 mm in each of the 3 trial sections. The sub-base had a constant thickness of 350 mm in the control section (see Item 200 aggregate sub-base). Thus, the longitudinal level of the subgrade was adjusted accordingly. The levels data provided in Appendix D indicates that the levels for the top of the subgrade were within 10mm of the design levels, and frequently within 5mm of the design levels.

The top of subgrade was graded to provide a cross-fall of 2.0% towards the ditch.

Results from the field density tests carried out after compaction are given in Table 3.4. The results for the right side of the road are for a different material type to that used on the left side and so it is not the material described for Item 105 above.

Table 3.4 Field density results for the blended subgrade used on the Left side

Laying date (estimated)	Lane	Section	Layer	Representing station:			Test Location		Results	
				from Km	to Km	length m	Km	Off set from CL m	Relative Density %	Rel. MC %
12-Apr-02	L	1	1	142.340	142.440	100	142.404	3.2	95.7	88.6
12-Apr-02	L	1	1	142.340	142.440	100	142.360	1.0	94.7	83.2
12-Apr-02	L	1	1	142.340	142.440	100	142.460	1.7	96.6	87.3
29-Apr-02	L	2	1	142.440	142.520	80	142.455	2.7	99.7	86.1
29-Apr-02	L	2	1	142.440	142.520	80	142.480	3.0	97.8	85.9
29-Apr-02	L	2	1	142.440	142.520	80	142.505	2.8	100.5	84.5
17-May-02	L	3	1	142.520	142.600	80	142.535	1.2	100.4	90.0
17-May-02	L	3	1	142.520	142.600	80	142.560	3.1	105.2	81.5
17-May-02	L	3	1	142.520	142.600	80	142.535	3.3	106.4	86.3
25-May-02	L	4	1	142.600	142.660	60	142.670	3.1	99.7	86.7
25-May-02	L	4	1	142.600	142.660	60	142.650	2.5	100.1	75.0
25-May-02	L	4	1	142.600	142.660	60	142.650	1.0	98.9	80.8
14-Jun-02	L	4	1	142.660	142.700	40	142.680	2.1	99.5	94.9
4-Jun-02	R	5	1	142.365	142.415	50	142.320	1.0	99.5	82.2
4-Jun-02	R	5	1	142.365	142.415	50	142.400	2.1	95.9	80.9
7-Jun-02	R	5	1	142.340	142.365	25	142.350	2.1	95.2	67.4
7-Jun-02	R	5	1	142.415	142.455	40	142.435	3.0	97.1	76.1
7-Jun-02	R	5	1	142.415	142.455	40	142.450	2.5	99.6	74.3
11-Jun-02	R	5	1	142.455	142.520	65	142.470	2.1	98.3	77.4
11-Jun-02	R	5	1	142.455	142.520	65	142.500	3.0	99.7	63.2
21-Jun-02	R	5	1	142.520	142.580	60	142.535	1.8	91.9	146.9
21-Jun-02	R	5	1	142.520	142.580	60	142.570	2.7	93.6	73.4
?	R	5	1	142.580	142.700	120	??	??	??	??

3.5.3 Construction of the sub-bases

Construction of the sub-base varied for each section of the trial.

Item 200 Aggregate sub-base course

The sub-base was prepared by the Contractor by blending the following materials in the proportions given below.

Table 3.4 Blend used for the aggregate sub-base

Supplier	Size/Source	Proportion %
Tysan	G1	30%
Tysan	3/8	20%
Robust	3/8	10%
Robust	S1	20%
Binder, Banilad	Banilad	20%

The engineering properties are given in Table 3.5 and the grading is given in Figure 3.2.

Table 3.5 Blended sub-base Item 200

Engineering Property	Unit	Result
Liquid Limit	%	18
Plastic Limit	%	11
Plasticity Index	%	7
Percentage passing 75µm	%	9.6
Type Class		A-2-4 (0)
Maximum Dry Density (T180)	Mg/m^3	1.98
Optimum Moisture Content	%	11.8
CBR at 95% of MDD	%	28
Swell at 100% MDD	%	2.2

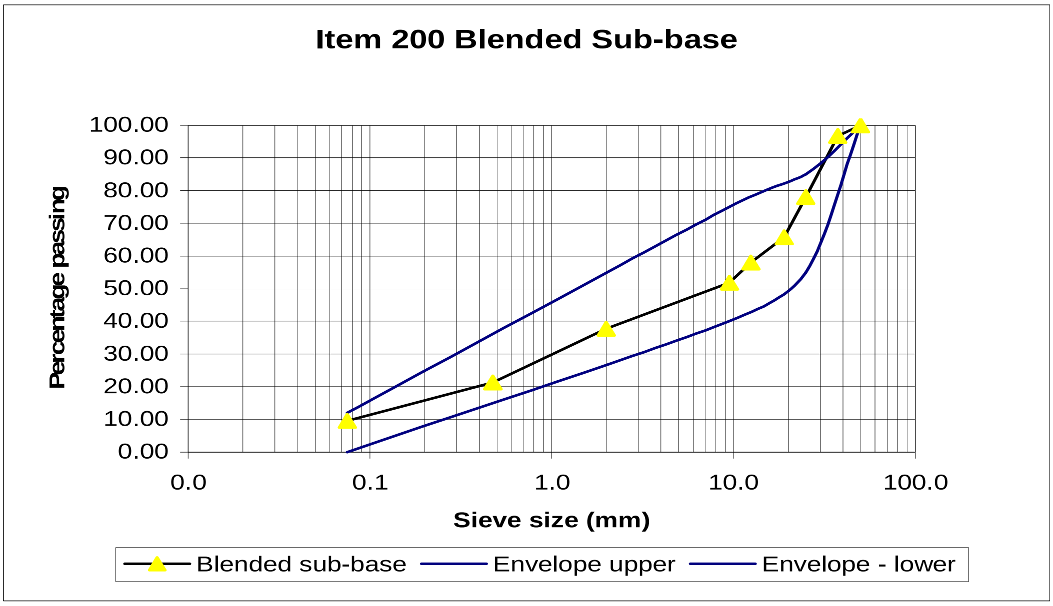


Figure 3.2 Grading of the blended sub-base used for Section 1

The blended material was processed to the optimum moisture content, as necessary, at the stockpile, hauled and placed on site. Placement extended across the shoulder to the side-slope, as required in the design. The sub-base was constructed in two equal layers, each 175mm compacted thickness, using a grader to spread the material and then compacted.

Some difficulties occurred during the construction of the Item 200 sub-base. Following heavy rain on Thursday the 18th April 2002, run-off water flowed over the compacted material and ponded at the end of the section. It was noted on Friday the 19th April 2002 that the fines had been washed from the sub-base material on the higher levels of the section towards the lower levels at the end of the section. This affected, in particular, the last 50 metres (142+390 to 142+440). The upper layer of sub-base was reprocessed on Monday the 22nd of April 2002.

It is noted that at the design density of 95% of the MDD obtained in the T180 compaction method, the material had a CBR of 28% in the soaked condition which is lower than the design CBR of 30%. It should also be noted that the material exhibited swelling while being wetted from the compaction moisture content to the soaked moisture content. The reported swell was 2.2%.

The densities obtained after compaction in the field are reported in Table 3.6. These show that the minimum density obtained in the field was 97%. Materials that are prone to swelling may do so if the in-situ moisture content increases above the placement moisture content. Materials that swell are subject to a reduction in density and therefore strength. Swelling may also be noticeable at the road surface. Propensity to swell is also dependant on the swelling pressure which is resisted by the static loading of the materials above the swelling material. This has not been reported. In the standard test (AASHTO: T93-98) the minimum mass is 4.54kg. The actual mass surcharge provided by the roadbase and the surfacing at the top of the sub-base would be approximately 12.5kg. If the minimum mass was used the amount of swell would be overestimated.

Table 3.6 Field Densities obtained for the blended sub-base used for Section 1

Laying date	Lane	Section	Layer	Representing station:			Test Location		Results	
				from Km	to Km	length m	Km	Off set from CL m	Relative Density %	Rel. MC %
15-Apr-02	L	1	1	142.340	142.440	100	142.351	1.0	100.2	59.3
15-Apr-02	L	1	1	142.340	142.440	100	142.382	3.0	100.1	71.2
15-Apr-02	L	1	1	142.340	142.440	100	142.429	2.8	99.2	81.4
17-Apr-02	L	1	2	142.340	142.440	100	142.363	2.1	98.8	66.9
17-Apr-02	L	1	2	142.340	142.440	100	142.390	2.2	97.0	98.3
17-Apr-02	L	1	2	142.340	142.440	100	142.420	3.0	98.5	80.5

The Test reports are given in Appendix H.

Item 200(1a) Stabilized sub-bases

Construction of the stabilized sub-base sections was carried out by reusing the existing sub-base material from the work site. The material was excavated and transported to the batching plant area at Banilad and stockpiled ready for processing with cement. By excavating the material from Section 1 (unbound sub-base) and replacing it with a new material, a stockpile reserve was established so that the stabilized sections could be readily and rapidly constructed.

Strength and therefore cement requirements had been determined in the design of the pilot trial. These were verified in the site laboratory. Table 3.7 gives the design and actual requirements.

Table 3.7 Design and requirements for the sub-bases

Requirement	Unit	Designated construction item		
		200(1a)	200(2a)	200(3a)
Designed strength	MPa	1	3	5
Cement required	% by weight	1	3	5
Volume of material	m^3	172	138	138
Quantity of cement per section	40 kg bags	61	147	245

Note: Section lengths differ.

The transported materials were tested in the Contractor's laboratory to confirm the data obtained during the design stages.

The raw material was tested and found to be a well-graded, non-plastic, sandy gravel. The maximum dry density was determined to be 1.816Mg/m^3 and the optimum moisture content was 14.5%. The grading is shown in Figure 3.3. These data were in good agreement with those determined during the design stages of the pilot trial.

Cement was then added to the material to determine the compaction characteristics for each blend. The data are given in Table 3.8 together with the data for the un-stabilized (raw) sub-base material.

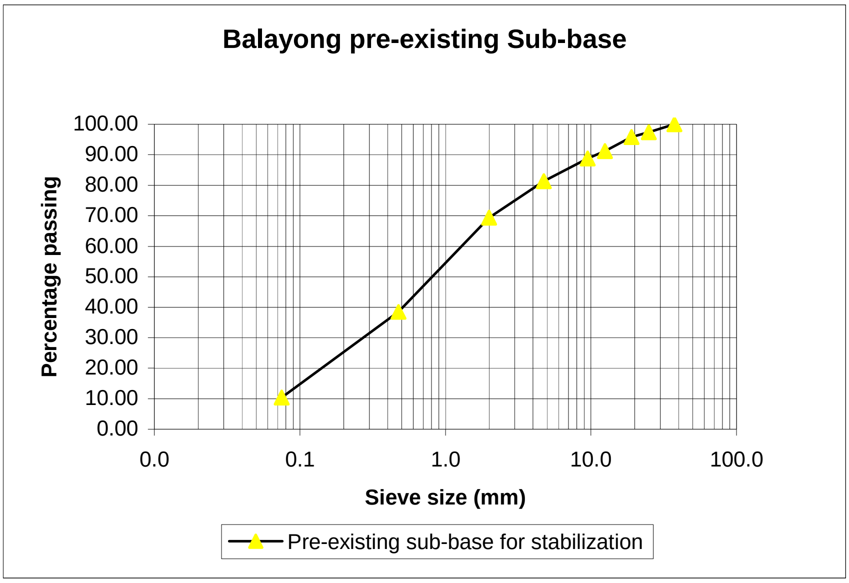


Figure 3.3 Grading of the pre existing sub-base

Table 3.8 Compaction and strength results for the stabilized sub-bases

Sample identity	MDD Mg/m^3	OMC %	CBR 95%MDD	CBR 100%MDD
Pre-existing sub-base	1.816	14.5	46	88
Plus 1% cement	1.759	12.2	108	119
Plus 3% cement	1.770	13.2	114	190
Plus 5% cement	1.809	13.6	159	182

Once cement in the required quantities was added, unconfined compressive strength testing (UCS) was carried out on the material, again to confirm the characteristics of the material at the construction phase.

A powered vibrating hammer was used to form specimens in moulds that were about 152 mm in diameter and which could be split to enable the specimens to be extracted. In general, the specimens were formed in accordance with BS 1924 (Stabilized Materials for Civil Engineering Purposes, 1990). A large representative bulk sample of the raw material was taken from the stockpile. This was sub-divided to obtain the quantity of material required for a series of tests and the cement was added. The specimens were formed in 3 layers to obtain a target height of 127mm, similar to the height of a CBR mould. In the various series of tests the material was tested to determine (a) the change in strength with density, by varying the time used to compact each layer; (b) the strength after 7 days curing; and (c) the strength after 14 days curing. A summary of the test results compared with each of the target strengths is given in Table 3.9. Further data is given in Appendix I.

Table 3.9 Strengths after 7 days curing

Section	Target strength MPa	Max Strength MPa	Adjusted strength MPa
2	3	4.59	3.99
3	5	7.51	6.53
4	1	2.31	2.01

Thereafter, to determine the strength of the materials that were to be laid, the stabilized materials were sampled from the truck loads of batched material before they left the batching plant. The full data set for the laboratory results is given in Appendix I. A summary of the strengths obtained on these materials is given below in Table 3.10. Data obtained for Section 4 (target 7-day strength of 1MPa) from the truck loads of batched materials has not been provided by the Contractor.

Table 3.10 Strengths obtained on the truck loads of batched materials

Laying date	Section	Layer	Representing station			Maximum strength MPa
			from km	to km	length m	
30-Apr-02	2	1	142.44	142.52	80	4.50
30-Apr-02	2	1	142.44	142.52	80	4.10
30-Apr-02	2	1	142.44	142.52	80	4.66
30-Apr-02	2	1	142.44	142.52	80	4.28
01-May-02	2	2	142.44	142.52	80	3.77
01-May-02	2	2	142.44	142.52	80	2.83
17-May-02	3	1	142.52	142.6	80	5.27
17-May-02	3	1	142.52	142.6	80	5.37
18-May-02	3	2	142.52	142.6	80	5.37
18-May-02	3	2	142.52	142.6	80	5.32

The sub-bases were constructed in two layers. The first layer was constructed with a varying thickness from 220mm to 70mm, from the thickest to the thinnest ends of the section, such that the second layer could be constructed with a constant thickness of 130mm throughout.

To ensure a monolithic layer, a cement slurry (Item SPL-2) was spread on the completed first layer of stabilized sub-base immediately before placement of the second layer. To form the slurry, cement was mixed with water to form a liquid paste which was then poured and brushed over the entire surface. The approximate mix was 60 litres of water to 1 bag of cement.

Compaction of the sub-base was carried out using vibrating rollers to achieve a minimum relative density of 95% of that obtained in the T180 laboratory compaction test. The field density results for the unbound and stabilized sub-bases are shown in Table 3.11. Once compaction was completed, the surface was covered with plastic sheeting to provide a temporary curing membrane over the exposed works for a period of 7 days or until the next, upper layer was placed. Views of the construction and curing of the stabilized sub-base are shown in Plate 2 and Plate 3, respectively.

The data and test reports are given in Appendix I.

Some complications occurred during the construction of Section 2. Field density testing of the second layer of stabilized sub-base in Section 2 indicated that the material was loose and broke out of the density hole too easily. It was considered to be unstabilized. This was attributed to either delays in delivery or low moisture contents during batching, or both. On May 6th 2002, the Contractor agreed to restabilize the second layer at his cost. Seventy-five 40kg bags of cement were required. The work was carried out on May 8th 2002. The in situ material was ripped using a grader and the bags of cement were spotted over the area. Blending was then completed by a grader, and then compaction was carried out. The cement slurry (Item SPL-2) was not used to rebond the newly processed layer with the lower layer.

Table 3.11 Field density results: stabilized sub-bases

Laying date	Lane	Section	Layer	Representing station:			Test Location		Results	
				from Km	to Km	length m	Km	Off set from CL m	Relative Density %	Rel. MC %
30-Apr-02	L	2	1	142.440	142.520	80	142.450	2.8	99.7	54.8
30-Apr-02	L	2	1	142.440	142.520	80	142.480	1.2	99.0	53.8
2-May-02	L	2	2	142.440	142.520	80	142.510	2.1	97.8	55.3
2-May-02	L	2	2	142.440	142.520	80	142.480	1.5	95.8	60.2
2-May-02	L	2	2	142.440	142.520	80	142.350	2.7	101.0	72.3
9-May-02	L	2	2	142.440	142.520	80	142.460	2.3	100.8	79.0
9-May-02	L	2	2	142.440	142.520	80	142.490	1.0	98.3	72.3
9-May-02	L	2	2	142.440	142.520	80	142.510	3.2	99.1	60.8
17-May-02	L	3	1	142.520	142.600	80	142.530	2.3	100.3	59.8
17-May-02	L	3	1	142.520	142.600	80	142.565	1.2	102.6	81.1
17-May-02	L	3	1	142.520	142.600	80	142.580	3.1	97.6	75.5
18-May-02	L	3	2	142.520	142.600	80	142.534	3.0	100.6	77.9
18-May-02	L	3	2	142.520	142.600	80	142.571	2.0	99.8	80.5
28-May-02	L	4	1	142.600	142.660	60	142.615	2.1	100.5	88.4
28-May-02	L	4	1	142.600	142.660	60	142.650	2.0	97.7	75.0
29-May-02	L	4	2	142.600	142.660	60	142.610	1.5	103.4	88.2
29-May-02	L	4	2	142.600	142.660	60	142.645	2.9	99.6	88.5
18-Jun-02	L	4	1	142.660	142.700	40	142.685	1.0	96.9	76.4
18-Jun-02	L	4	1	142.660	142.700	40	142.665	2.1	97.6	69.8
19-Jun-02	L	4	2	142.660	142.700	40	142.678	1.0	99.4	95.5

Plate 2 Construction of the stabilized sub-base

Plate 3 Curing the stabilized sub-base

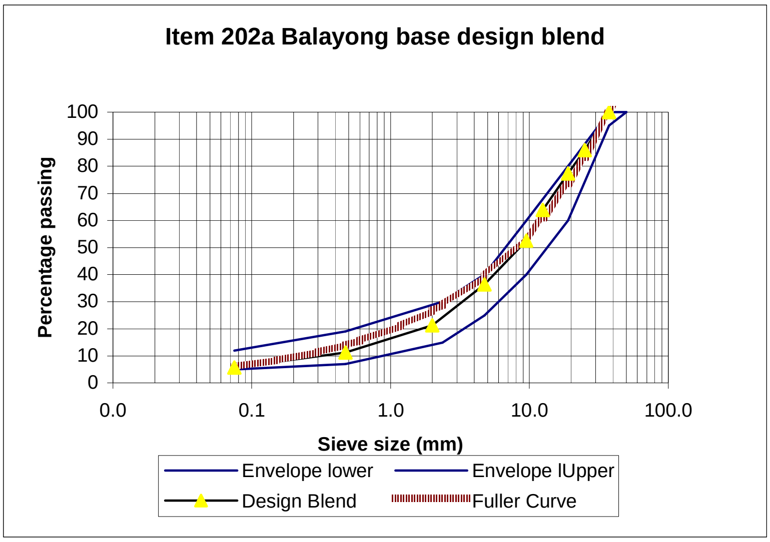


Figure 3.4 Design grading envelope for roadbase

3.5.4 Construction of the base course

Item 202(a) Crushed aggregate base course

The base material was required to comply with the aggregate properties and grading of the material as given in Appendix D. In other respects, the properties were required to comply with the Standard Specifications.

Trial blends of the raw materials that were in common use on the main Contract were calculated by varying the proportions and the resulting mix was compared with the grading envelope. From this it could be seen that none of the wide range of available aggregates could be blended to produce the required grading. It was possible to remain within the grading envelope but the various portions frequently alternated between meeting the upper or lower requirement and, thus, the resultant grading curve was *not* approximately parallel to the envelope, as is required. To resolve the problem the Contractor was shown that the addition of a small proportion of lime to the blend altered the grading sufficiently to meet the requirements. The addition of lime at 4%, 2% and 1.5% of the total dry weight of the other materials in the blend was tried and, on the basis of the tests carried out, the addition of 1.5% was deemed the most appropriate. The grading envelope and approved blend are shown in Figure 3.4, above.

As well as considering the resultant grading curve, compaction tests and CBR strength tests were carried out on the blends. It was noted that the addition of 4% lime decreased the soaked strength of the material slightly from 97% to 88% at the specified density of 95% of the maximum density obtained in the laboratory. However, the tests were carried out in different laboratories and therefore differences of this magnitude may be not significant. The addition of 4% lime also decreased the maximum density and increased the optimum moisture content, which is expected.

A further consideration was the volume of lime that was to be added to the blend. This is because the specific gravity of the lime is significantly lower than that of the other materials such that the usual determination by weight will lead to a larger than expected volume of lime being added. Determinations by weight are a convenience because determination by volume is difficult. A dense strong mix is, of course, determined by volume, not weight.

The Contractor was further advised that, to achieve a consistent mix, he may wish to blend the materials in a batching plant. The Contractor elected to use this approach and the material was blended in the CTB mixing plant at Banilad.

The approved blend and the properties of the individual materials are shown in Table 3.12. Further details are given in Appendix J. It will be noted that the Contractor's records frequently refer to *lime-treated base course*. This is not a correct use of the term. In common terminology '*lime treated*' refers to a cementitious product whereas in this case lime will not cement the other materials in the mix because they do not exhibit plasticity. The lime merely acts as a mineral filler and, thereby, improves the grading and the frictional and interlock properties of the mix to increase stability. As required in the design, the properties of an unbound base are retained.

Table 3.12 Blend and properties of the graded crushed stone base

Property	Specification	AASHTO Test	Aggregates (Rockworks)			Sand	Lime
			G1	3/4	3/8	Crushed	Agricultural
Blend	%		30	23	15	30.5	1.5(1)
Specific G(2)	NA	T85(2)	2.690	2.680	2.524	2.603	2.467
Absorption	NA		1.380	1.630	2.970	1.960	NA
Soundness(3)	<12	T104-77	5.8	5.4	6.95	7.2	
Abrasion	< 45%	T96	24.4	26.6	27.9	NA	NA
Fractured faces	100%		100	100	100	NA	NA
Plasticity	NP	T27	NP	NP	NP	NP	

Notes
(1) Of total weight of dry blended aggregates
(2) Oven dry
(3) SSS test

The batched roadbase material was dispensed into tipper trucks, then covered and hauled to the work site, a journey of 1 to 2 hrs depending on public traffic.

To prove the operations, the first 35metres of the trial site were declared a compaction trial, being the length from 142+340 to 142+375 on the left-hand side. The paver first spread the material in the traffic lane portion of the road then reversed and spread the remaining width, which was nominally under the road shoulder, to complete the full width. The roadbase was constructed in one layer. Compaction was carried out using both vibratory and pneumatic tyred rollers until the specified density was achieved. Operations proved to be satisfactory and the procedure was adopted for the remaining works. The field densities that were obtained are shown in Table 3.13. A view of the base construction is given in Plate 4.

Some complications occurred during construction.

During the construction of the roadbase (Item 202a) in Section 3 (142.520 to 142.600) heavy rain on the 21st or early on the 22nd May 2002, eroded the surface. Corrections were made using additional material and the surface was primed on May 22nd.
On May 29th 2002, part of Section 4 between 142.600 and 142.660 was damaged immediately after compaction by sudden heavy rainfall. The area was repaired on the same day and was primed on May 30th, 2002. The first layer of surfacing was laid (Item 310). However, by June 5 cracking in the

surfacing was noted within the limits 142.600 and 142.630. Movement was seen and it was deduced that the base (Item 200a) had been sealed while still saturated from the rain on May 29th, 2002. The surfacing was removed and the base was repaired. The surfacing was reapplied on June 7, 2002.

Table 3.13 Crushed stone base course: field densities achieved

Laying date	Lane	Layer	Representing station:			Test Location		Results	
			from Km	to Km	length m	Km	Off set from CL m	Relative Density %	Rel. MC %
3-May-02	L	1	142.340	142.440	100	142.350	1.2	95.8	85.4
4-May-02	L	1	142.340	142.440	100	142.360	1.2	102.8	89.5
7-May-02	L	1	142.340	142.440	100	142.380	3.0	100.0	94.0
7-May-02	L	1	142.340	142.440	100	142.383	1.3	100.0	81.2
7-May-02	L	1	142.340	142.440	100	142.390	1.3	100.3	75.0
7-May-02	L	1	142.340	142.440	100	142.410	2.9	101.7	95.3
7-May-02	L	1	142.340	142.440	100	142.410	2.9	101.8	92.8
7-May-02	L	1	142.340	142.440	100	142.430	2.1	100.9	80.9
7-May-02	L	1	142.340	142.440	100	142.430	2.1	100.6	86.0
7-May-02	L	1	142.340	142.440	100	142.430	3.0	100.3	88.5
9-May-02	L	1	142.440	142.520	80	142.450	2.9	103.0	89.3
9-May-02	L	1	142.440	142.520	80	142.455	2.9	103.3	86.0
3-May-02	L	1	142.440	142.520	80	142.480	1.2	104.7	83.4
9-May-02	L	1	142.440	142.520	80	142.480	2.9	106.5	78.1
9-May-02	L	1	142.440	142.520	80	142.480	2.9	105.9	87.1
9-May-02	L	1	142.440	142.520	80	142.510	3.0	100.3	94.3
9-May-02	L	1	142.440	142.520	80	142.510	3.0	100.0	95.3
21-May-02	L	1	142.520	142.600	80	142.530	2.0	101.2	94.3
21-May-02	L	1	142.520	142.600	80	142.550	3.0	102.3	84.7
21-May-02	L	1	142.520	142.600	80	142.580	2.4	102.3	91.3
6-Jun-02	L	1	142.600	142.660	60	142.611	2.1	100.6	94.3
6-Jun-02	L	1	142.600	142.660	60	142.640	2.7	101.4	96.9
19-Jun-02	L	1	142.665	142.700	35	142.685	1.6	102.9	109.1

Plate 4 Construction of the crushed stone base

3.5.5 Construction of the surfacing

Item 301 Bituminous prime coat.

The roadbase was primed before the application of the tack coat. The bitumen type was SHELL MC70-S1. It was spread at a temperature of 40^{O}C (the specification for its use is between 20 ^{O}C and 70 ^{O}C).

The Contractor used either a bitumen distributor or a hand-lance to apply the prime. The required spray rate was 1.5L/m^2 . Two or three trays were laid out in the usual way and the weight of bitumen on the trays was weighed. The average spray rates applied are given in Table 3.14. A summary of the data and the data sheets are given in Appendix E.

Table 3.14 Application rate for the prime coat

Laying date	Lane	Station		Average rate of application L/sq.m
		from km	to km	
09-May-02	left	142.340	142.440	1.585
08-May-02	left	142.440	142.520	1.513
22-May-02	left	142.520	142.600	1.543
30-May-02	left	142.600	142.660	1.542
20-Jun-02	left	142.660	142.700	1.502
05-Jun-02	right	142.365	142.415	1.593
07-Jun-02	right	142.415	142.465	1.487
13-Jun-02	right	142.465	142.520	1.517
24-Jun-02	right	142.520	142.600	1.543
24-Jul-02	right	142.630	142.672	1.504
25-Jul-02	right	142.672	142.700	1.479
07-Jun-02	????	142.600	142.660	1.559

Item 302 Bituminous tack coat.

The tack coat was to be placed before the application of each layer of the asphalt concrete (Item 310). Application rates are given in Table 3.15. There is no indication on the data sheets to determine which layer is being reported and there is insufficient data for it to be the report for both layers. It is likely that the data provided is for the first layer and therefore no data has been provided for the second layer.

Table 3.15 Application rates for the tack coats

Laying date	Layer	Lane	Station		Average rate of L/sq.m	Reference	Notes
			from km	to km			
10-May-02	??	left	142.340	142.520	0.500	SS1h-014	
23-May-02	??	left	142.515	142.600	0.495	SS1h-016	
31-May-02	??	left	142.600	142.660	0.493	SS1h-018	
24-Jun-02	??	left	142.660	142.700	0.526	SS1h-019	
07-Jun-02	??	left	142.600	142.660	0.498	SS1h-023	Duplicated
07-Jun-02	??	right	142.365	142.415	0.505	SS1h-021	
08-Jun-02	??	right	142.415	142.520	0.506	SS1h-022	
25-Jun-02	??	right	142.520	142.580	0.532	SS1h-024B	
17-Jun-02	??	right	142.580	142.700	0.503	SS1h-023x	

Item 310 Bituminous surface course (Grading B)

The bituminous mix design used for the asphalt concrete wearing course was the same as that approved for the main Contract LZH-D. In accordance with the mix, the grading of the aggregates were to conform to Grading B of the Standard Specifications and the asphalt cement content was between 5 and 7% of the total mix by weight. Once the design mix was established, samples were taken from the paver on each day of laying to determine the properties of the actually mixed material in use. The tests included extraction of binder and grading analysis, and the determination of the Marshall Stability. The data are shown in Table 3.16 and Table 3.17, respectively.

Table 3.16 Bitumen content and grading for Item 310

Laying date	Lane	Layer	Representing station:		AC	Grading pass/ fail
			from	to	%	
10-May-02	L	1	142.340	142.520	5.71	Pass
23-May-02	L	1	142.520	142.600	5.69	Pass
01-Jun-02					5.73	Pass
05-Jun-02	R	1	142.365	142.415	5.61	marginal
07-Jun-02					5.78	Pass
08-Jun-02					5.76	Pass
14-Jun-02					5.69	Pass
24-Jun-02					5.56	Pass
25-Jun-02					5.66	Pass
17-Jul-02					5.63	Pass

Table 3.17 Marshall properties of laid material

Laying date 2002	AC (Bitumen) content %	Flow (avg) mm	Air voids %	VMA %	VFB (VFAC) %	Stability		
						0.5 hrs kg	24 hrs kg	Loss %
10 May	5.71	3.1	3.5	14.8	76.1	1670	1288	22.9
23 May	5.69	3.1	3.5	14.8	76.4	1606	1328	17.3
1 Jun	5.73	3.1	3.8	14.9	74.6	1612	1302	19.2
5 Jun	5.61	3.2	3.5	14.7	76.0	1671	1301	22.1
7 Jun	5.78	3.0	3.8	14.9	74.7	1580	1227	22.3
8 Jun	5.76	3.1	3.8	15.0	74.5	1593	1294	18.8
14 Jun	5.69	3.1	4.0	14.7	72.8	1233	1023	17.0
24 Jun	5.56	3.9	3.9	14.7	73.8	1252	1007	19.6
25 Jun	5.66	3.1	3.8	14.8	74.6	1214	1041	14.3
17 Jul	5.63	3.5	3.8	14.5	73.6	1436	1250	13.0

The asphalt concrete wearing course was constructed in two layers, each 50mm thick. Cores were taken after construction and the thickness and relative density obtained are given in Table 3.18. Summaries of the data test sheets are given in Appendix K.

Table 3.18 Core thickness and density

Date 2002	Lane	Representing station		Core location Km	Thickness mm	Compaction %
		From Km	To Km			
10 May	left	142.340	142.440	142.360	50	98.6
10 May	left	142.440	142.540	142.460	55	99.9
10 May	left	142.540	142.600	142.560	67	99.8
8 Jun	right	142.340	142.700	142.350	51	99.1
14 Jun	right	142.340	142.700	142.450	46	99.4
25 Jun	right	142.340	142.700	142.550	51	99.2
26 Jul	right	142.340	142.700	142.650	60	98.8

3.6 Construction of the eastbound traffic lane (to Bauan)

Works on this traffic lane were similar to those carried out for the structural overlay of the road carried out under Contract LZH-D. The deviation (SPL-1) was removed. The works are described below.

3.6.1 Excavations and preparation of the sub-base

Item 101(3a) Removal of existing asphalt concrete

The existing asphalt concrete was broken out and removed to waste in accordance with the procedures established for the Contract LZH-D.

Item 102(2a) Excavation of existing cement treated base course

The existing CTB was excavated throughout the eastbound traffic lane of the trial section.

Item 200(4a) Preparation of sub-base

Generally, the sub-base was prepared in accordance with the requirements of Contract LZH-D. To accommodate the requirement to maintain the existing final road levels, approximately 50mm of the existing sub-base was removed. This allowed for the increased thickness of the bituminous surfacing (100mm) compared with the existing surfacing (50mm). The thickness and strength of the existing sub-base and the underlying imported layer (subgrade) was sufficient to accommodate the removal of this thickness of material.

3.6.2 Construction of the cement treated base course

Item 206 Portland cement treated base course

As required in the specifications, the design mix for the Cement Treated Base course was based on that used for the main contract LZH-D. In the special specifications for LZH-D a percentage of cement was required rather than strength criteria. The amount of Portland cement to be added to the crushed aggregate was 4% by mass of dry crushed aggregate for central plant mix, and 4.5 mass per cent of dry crushed aggregate for portable plant mix. As mentioned above, the requirement for the strength criteria given in the Standard Specifications (sub-section 204.2.5) was deleted.

Notwithstanding the above, and prior to construction, the properties of the raw and blended materials were reconfirmed and the strength of the mix was verified in the laboratory. A technical summary of the proportions used and the properties of the blend are given below in Table 3.19, and the designed blend is given in Figure 3.5. The data are given in Appendix L.

Table 3.19 Properties of CTB materials

Property	Specification	AASHTO	Aggregates		Sands		Cement
	Units	Test	G1 Taysan	¾ inch Taysan	Crushed Taysan	Natural Agoncillo	Portland OPC
Blend	%		25	20	45	10	4.5 (1)
Specific Gravity	Mg/m^3	T85(2)	2.690	2.680	2.603	2.496	3.15
Absorption	%		1.38	1.63	1.96	2.67	
Soundness(3)	12% max.	T104-77	5.8	6.0	7.2	8.2	
Abrasion	≤ 45%	T96	24.4	26.6			
Fractured faces[4]	≥ 50%	ASTM D 5821-95	100	100			
Plasticity	< 6	T27	NP	NP	NP	NP	

Notes:
(1) Of total weight of dry blended aggregates
(2) Oven dry
(3) SSS test (5 cycles)
(4) See Appendix F

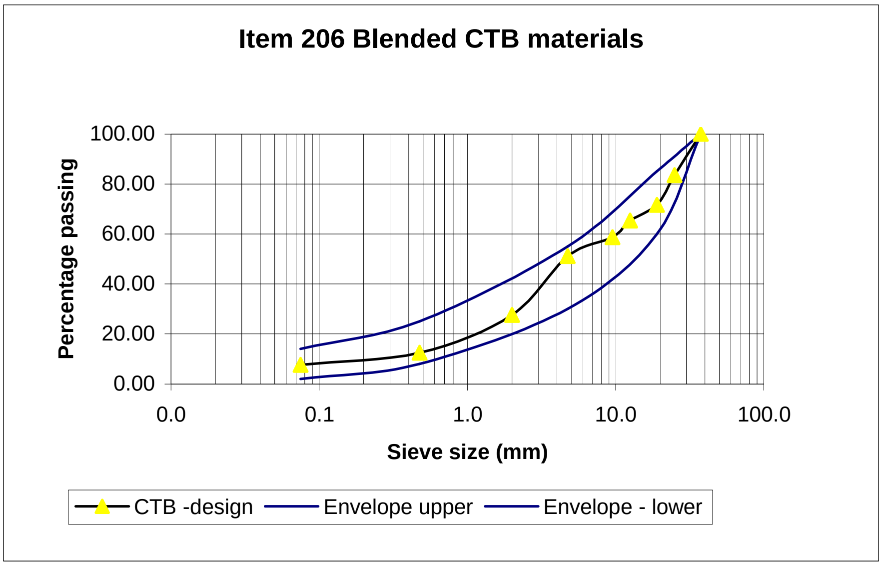


Figure 3.5 Grading of the blended CTB materials

A requirement of the grading of the blended material is that the material portion passing the 75micron sieve must be less than 66 per cent of the fraction passing the 0.435mm sieve.

Laboratory compaction tests (AASHTO, T180 method) and CBR strength tests were carried out. The maximum dry density of the blend without cement was found to be 2.160 Mg/m^3 at an optimum moisture content of 9.8 per cent. Using the soaked CBR method, the soaked strength was found to be 110% at 100% of the maximum dry density and 105% at 95% of the maximum dry density. The CBR strength requirement for the blended aggregates was reported to be 80%. Strength testing was also carried out on the blended aggregates with cement added. The laboratory compaction level was 95% of the maximum obtained and these tests showed that the strength of the material after curing and soaking for 4 days was 350 per cent. Measurement of CBR at these very high strengths is not accurate and the material should be regarded as having substantial and adequate strength.

Batching of the materials was carried out using a central plant mix method. The plant was located at the Contractor's main office and equipment yard at Banilad. Materials were then hauled to the work site in covered tipper trucks.

In accordance with the modified specifications, the CTB, being thicker than 200mm, was laid in two approximately equal layers each 125mm thick. Compaction was carried out on the spread and smoothed layer using approved compaction equipment to achieve a field density of not less than 100% of the compacted maximum dry density determined in accordance with AASHTO T180, Method D. Field density testing was carried out in accordance with AASHTO T191 with a minimum frequency of one test per one-day production. A summary of the field densities obtained for each layer relative to that obtained in the laboratory is shown in Table 3.20. Layer 2 is the upper layer. The Table also shows the moisture content of the compacted materials relative to the optimum obtained in the laboratory.

After the cement treated base course had been finished, the surface was protected against drying for a period of at least five (5) days, or until the next pavement layer was placed, or until the Bituminous Prime Coat was applied. To prevent drying, the surface was kept moist by sprinkling with water and then by covering the area with a durable and impermeable plastic sheet.

Table 3.20 Summary of CTB field densities achieved

Laying date	Lane	Layer	Representing station			Test Location		Results	
			from Km	to Km	length m	Km	Off set from CL m	Relative Density %	Rel. MC %
8-Jun-02	R	1	142.340	142.365	25	142.355	3.0	101.7	80.0
5-Jun-02	R	1	142.365	142.415	50	142.375	1.8	100.0	85.0
5-Jun-02	R	1	142.365	142.415	50	142.410	2.1	100.3	91.0
8-Jun-02	R	1	142.415	142.455	40	142.430	1.5	101.7	93.0
8-Jun-02	R	1	142.415	142.455	40	142.445	2.7	100.9	78.0
8-Jun-02	R	1	142.415	142.455	40	142.450	2.7	100.6	99.0
11-Jun-02	R	1	142.455	142.520	65	142.470	1.7	101.3	93.0
11-Jun-02	R	1	142.455	142.520	65	142.515	2.1	100.7	65.0
28-Jun-02	R	1	142.580	142.630	50	142.520	2.1	101.4	78.0
21-Jun-02	R	1	142.520	142.580	60	142.530	3.0	99.8	81.0
21-Jun-02	R	1	142.520	142.580	60	142.570	1.0	100.1	87.0
28-Jun-02	R	1	142.560	142.630	70	142.590	3.0	100.9	114.0
23-Jul-02	R	1	142.630	142.672	42	142.650	1.0	100.7	68.0
25-Jul-02	R	1	142.670	142.700	30	142.685	1.5	101.2	78.0
5-Jun-02	R	2	142.340	142.365	25	142.355	2.9	100.1	94.0
8-Jun-02	R	2	142.340	142.365	25	142.355	1.2	100.1	84.0
8-Jun-02	R	2	142.415	142.455	40	142.430	1.1	101.3	90.0
12-Jun-02	R	2	142.455	142.520	65	142.470	3.1	100.3	92.0
12-Jun-02	R	2	142.455	142.520	65	142.500	2.0	100.6	87.0
29-Jun-02	R	2	142.580	142.630	50	142.595	2.0	101.2	70.0
29-Jun-02	R	2	142.580	142.630	50	142.615	3.0	100.3	80.0
23-Jul-02	R	2	142.630	142.672	42	142.660	1.0	101.5	62.0
25-Jul-02	R	2	142.670	142.700	30	142.675	2.8	100.7	68.0

3.6.3 Construction of the surfacing

Right lane: Items 301, 302 and 310: Bituminous prime coat, tack coat and asphalt concrete

The bituminous materials were applied to the right lane using the same method and equipment as the left lane. Data obtained for the right lane is given in the tables above.

3.7 Other construction items: drains shoulders signage and furniture

Item SPL-3 Drain (grouted rip-rap)

Drainage works were carried out according to the requirements given in the specifications. Initially earth drains were formed and thereafter these were shaped and reconstructed to form grouted rip-rap drains on both sides of the road and throughout the length of the pilot trial. The Contractor was required to drill the lined drains at frequent intervals to readily allow the passage of any water from within the graded crushed stone base to reach the drain. The drains were connected to the existing lined or earth drains at each end of the pilot trial length.

Item 300 Aggregate surface course (shoulders)

Where the crushed stone roadbase was used it was necessary to maintain the subsurface ‘within-layer’ drainage. The shoulder was constructed using the aggregate surface materials conforming to the DPWH Standard Specifications.

Item 605 Road sign

An information sign was placed at each end of the trial to indicate to the public that the construction was a pilot trial.

Road marking and furniture

Road marking and placement of furniture were carried out in accordance with the requirements of Contract LZH-D.

4 ACKNOWLEDGEMENTS

This report was jointly produced by the Infrastructure Division of TRL Ltd (Director Mr M Head) and by The Bureau of Research and Standards (Director Mr A V Molano, JR), Department of Public Works and Highways, Philippines. The project was carried out on behalf of the Department for International Development, UK and the Department of Public Works and Highways, GoP. The research was carried out in the Research and Development Division of BRS and their valuable co-operation has been essential to the success of this project.

Appendix A. Construction drawings

Plan of trial

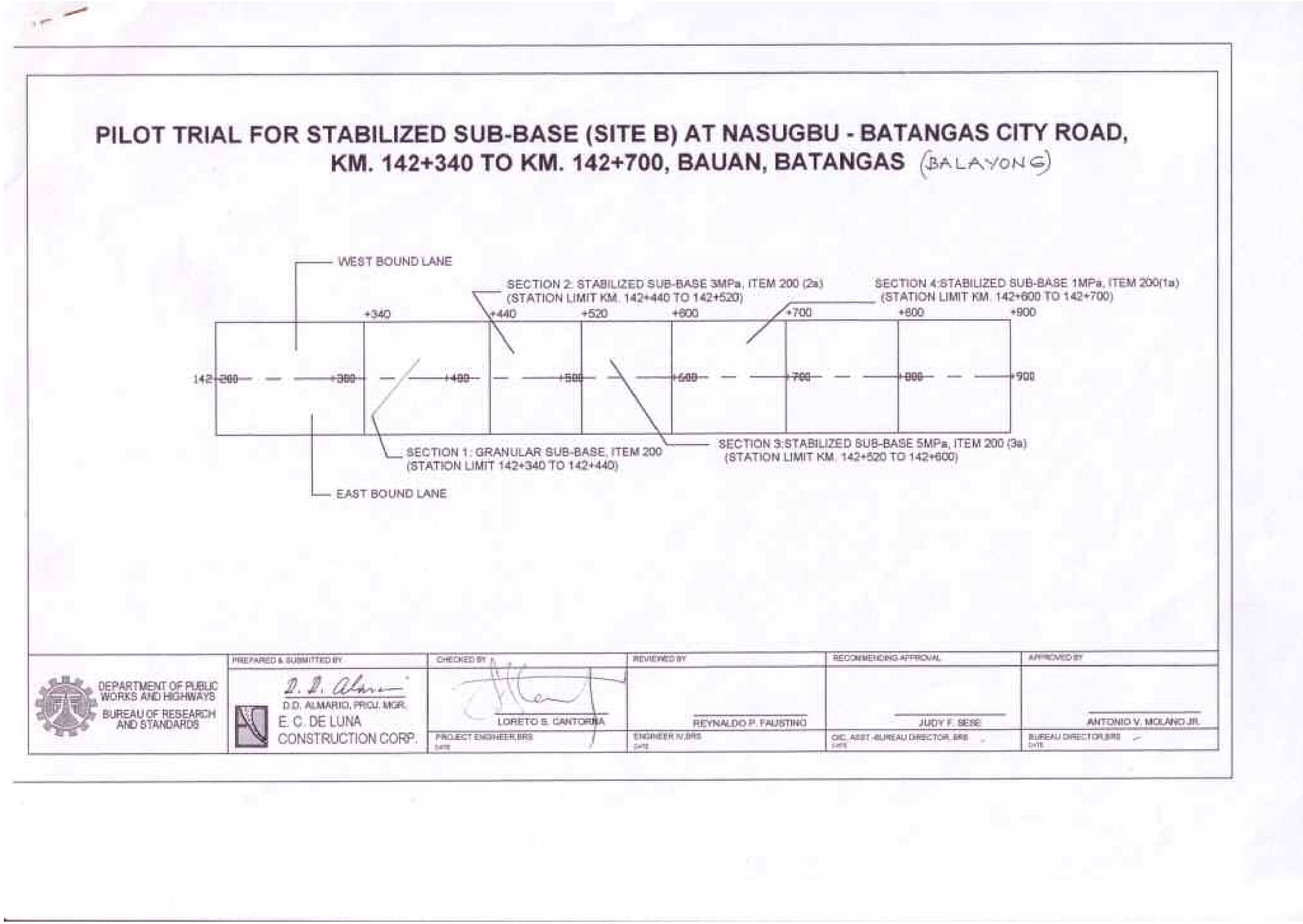
Longitudinal cross-section

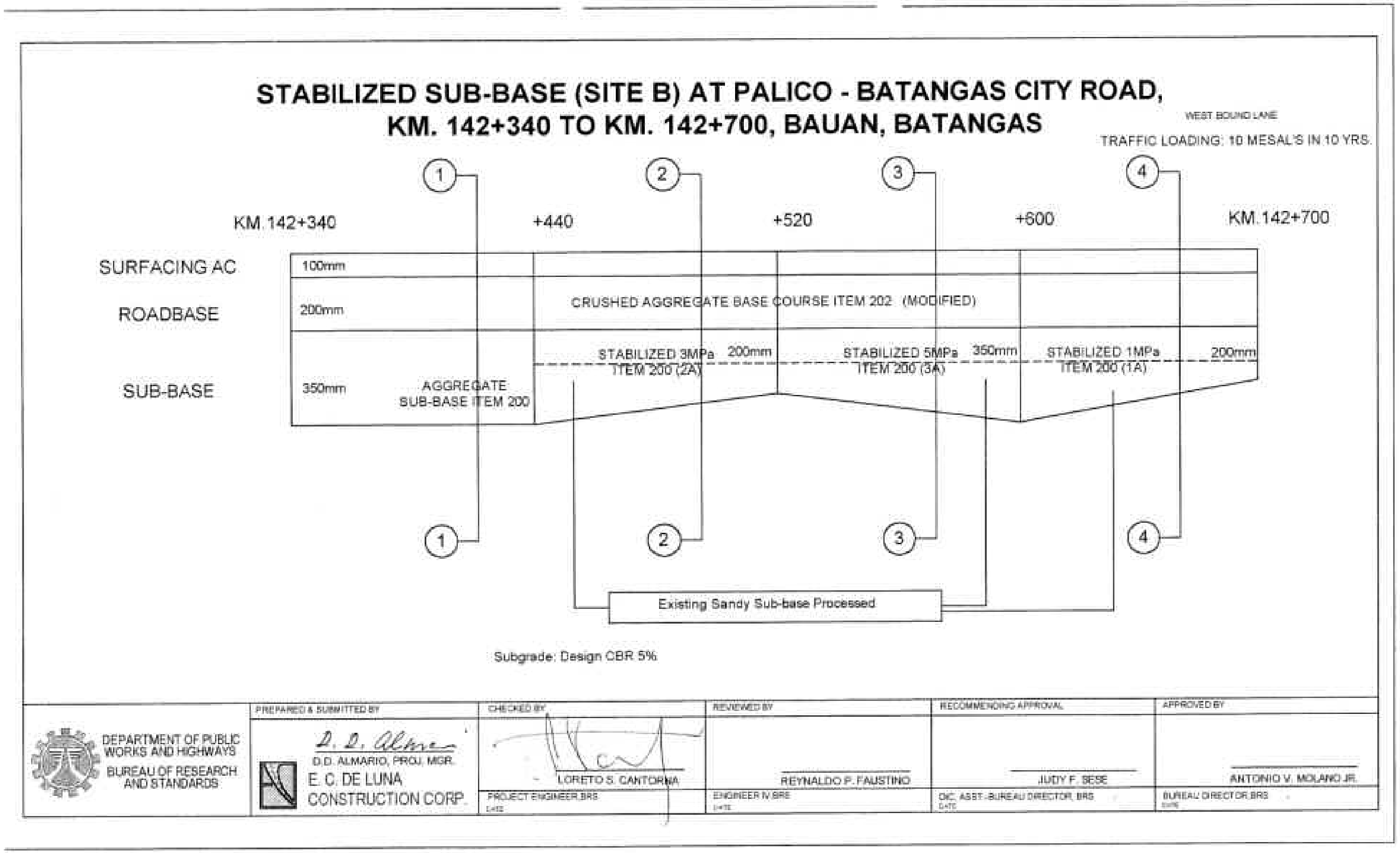
Transverse cross-section of Section 1

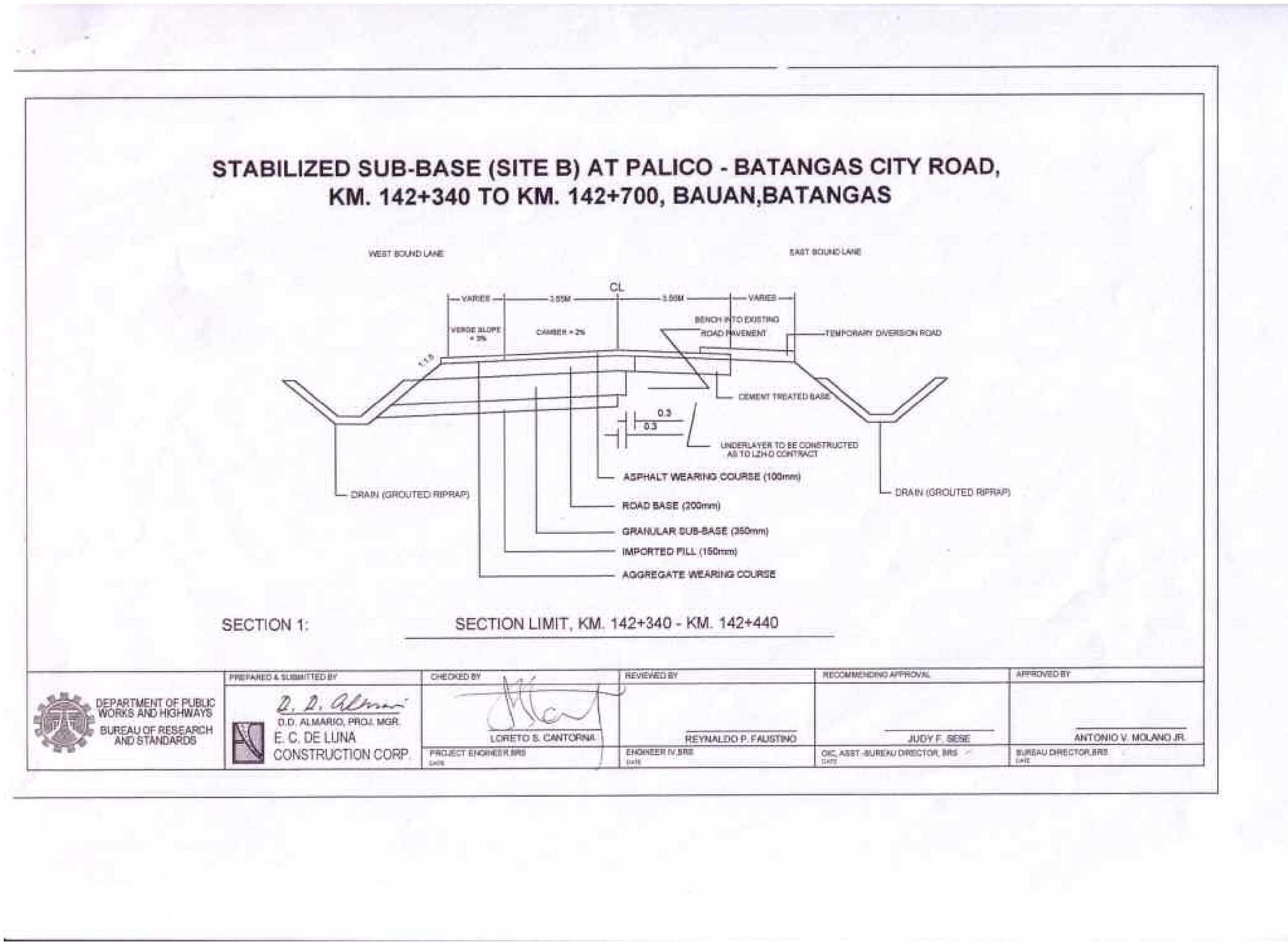
Transverse cross-section of Section 2

Transverse cross-section of Section 3

Transverse cross-section of Section 4


PILOT TRIAL FOR STABILIZED SUB-BASE (SITE B) AT NASUGBU - BATANGAS CITY ROAD,
KM. 142+340 TO KM. 142+700, BAUAN, BATANGAS (BALAYONG)
WEST BOUND LANE
SECTION 2: STABILIZED SUB-BASE 3MPa, ITEM 200 (2a)
(STATION LIMIT KM. 142+440 TO 142+520)
SECTION 4:STABILIZED SUB-BASE 1MPa, ITEM 200(1a)
(STATION LIMIT KM. 142+600 TO 142+700)
+340
+440
+520
+600
+700
+800
+900
142+200
+300
+400
+500
+600
+700
+800
+900
SECTION 1: GRANULAR SUB-BASE, ITEM 200
(STATION LIMIT 142+340 TO 142+440)
SECTION 3:STABILIZED SUB-BASE 5MPa, ITEM 200 (3a)
(STATION LIMIT KM. 142+520 TO 142+600)
EAST BOUND LANE
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
BUREAU OF RESEARCH AND STANDARDS
PREPARED & SUBMITTED BY
D.D. ALMARIO, PROJ. MGR.
E. C. DE LUNA CONSTRUCTION CORP.
CHECKED BY
LORETO S. CANTORNA
PROJECT ENGINEER,BRS
REVIEWED BY
REYNALDO P. FAUSTINO
ENGINEER IV,BRS
RECOMMENDING APPROVAL
JUDY F. SESE
OIC, ASST.-BUREAU DIRECTOR, BRS
APPROVED BY
ANTONIO V. MOLANO JR.
BUREAU DIRECTOR,BRS


STABILIZED SUB-BASE (SITE B) AT PALICO - BATANGAS CITY ROAD,
KM. 142+340 TO KM. 142+700, BAUAN, BATANGAS
WEST BOUND LANE
TRAFFIC LOADING: 10 MESAL'S IN 10 YRS.
KM.142+340
+440
+520
+600
KM.142+700
SURFACING AC
ROADBASE
SUB-BASE
100mm
200mm
350mm
CRUSHED AGGREGATE BASE COURSE ITEM 202 (MODIFIED)
AGGREGATE SUB-BASE ITEM 200
STABILIZED 3MPa ITEM 200 (2A)
200mm
STABILIZED 5MPa ITEM 200 (3A)
350mm
STABILIZED 1MPa ITEM 200 (1A)
200mm
1
2
3
4
Existing Sandy Sub-base Processed
Subgrade: Design CBR 5%
PREPARED & SUBMITTED BY
CHECKED BY
REVIEWED BY
RECOMMENDING APPROVAL
APPROVED BY
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
BUREAU OF RESEARCH AND STANDARDS
D.D. ALMARIO, PROJ. MGR.
E. C. DE LUNA CONSTRUCTION CORP.
LORETO S. CANTORNA
PROJECT ENGINEER BRS
REYNALDO P. FAUSTINO
ENGINEER IV BRS
JUDY F. SESE
OIC, ASST. BUREAU DIRECTOR, BRS
ANTONIO V. MOLANO JR.
BUREAU DIRECTOR BRS


STABILIZED SUB-BASE (SITE B) AT PALICO - BATANGAS CITY ROAD,
KM. 142+340 TO KM. 142+700, BAUAN,BATANGAS
WEST BOUND LANE
EAST BOUND LANE
CL
VARIES
3.55M
3.55M
VARIES
VERGE SLOPE = 3%
CAMBER = 2%
BENCH INTO EXISTING ROAD PAVEMENT
TEMPORARY DIVERSION ROAD
CEMENT TREATED BASE
0.3
0.3
UNDERLAYER TO BE CONSTRUCTED AS TO LZH-D CONTRACT
ASPHALT WEARING COURSE (100mm)
DRAIN (GROUTED RIPRAP)
DRAIN (GROUTED RIPRAP)
ROAD BASE (200mm)
GRANULAR SUB-BASE (350mm)
IMPORTED FILL (150mm)
AGGREGATE WEARING COURSE
SECTION 1:
SECTION LIMIT, KM. 142+340 - KM. 142+440
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
BUREAU OF RESEARCH AND STANDARDS
PREPARED & SUBMITTED BY
D.D. ALMARIO, PROJ. MGR.
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REVIEWED BY
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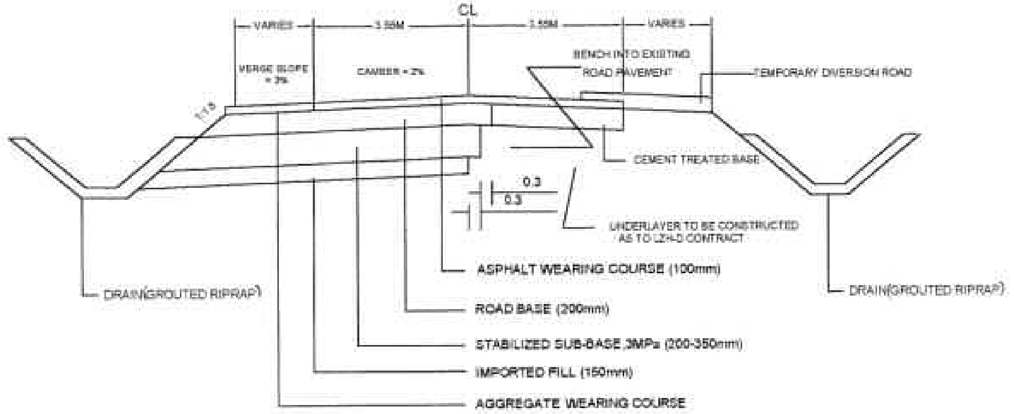
ANTONIO V. MOLANO JR.
BUREAU DIRECTOR,BRS

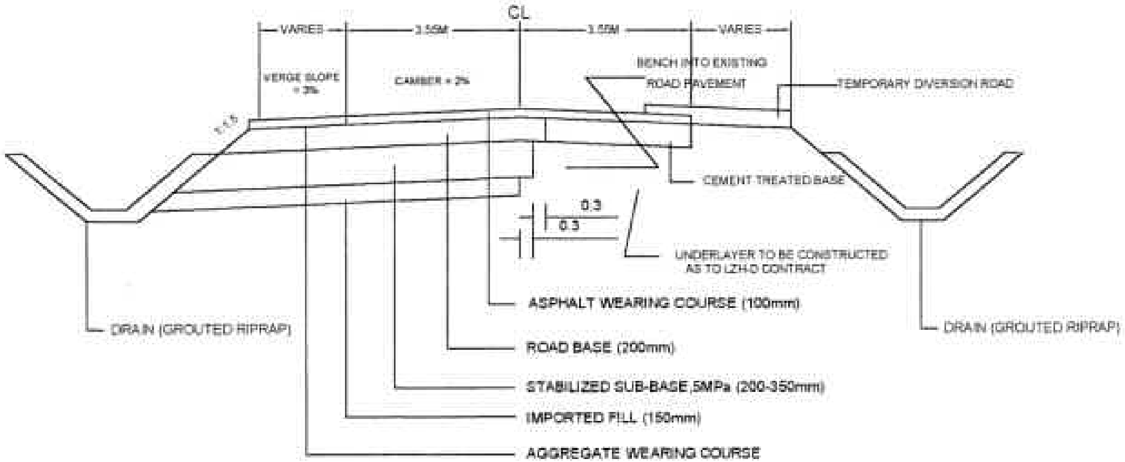
STABILIZED SUB-BASE (SITE B) AT PALICO - BATANGAS CITY ROAD, KM. 142+340 TO KM. 142+700, BAUAN,BATANGAS



SECTION 2: SECTION LIMIT, KM. 142+440 - KM. 142+520

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS BUREAU OF RESEARCH AND STANDARDS	PREPARED & SUBMITTED BY D.D. ALMARIO, PROJ. MGR. E. C. DE LUNA CONSTRUCTION CORP.	CHECKED BY LORETO S. CANTORNA PROJECT ENGINEER,BRS DATE	REVIEWED BY REYNALDO P. FAUSTINO ENGINEER IV,BRS DATE	RECOMMENDING APPROVAL JUDY F. SESE OIC, ASST.-BUREAU DIRECTOR, BRS DATE	APPROVED BY ANTONIO V. MOLANO JR. BUREAU DIRECTOR,BRS DATE

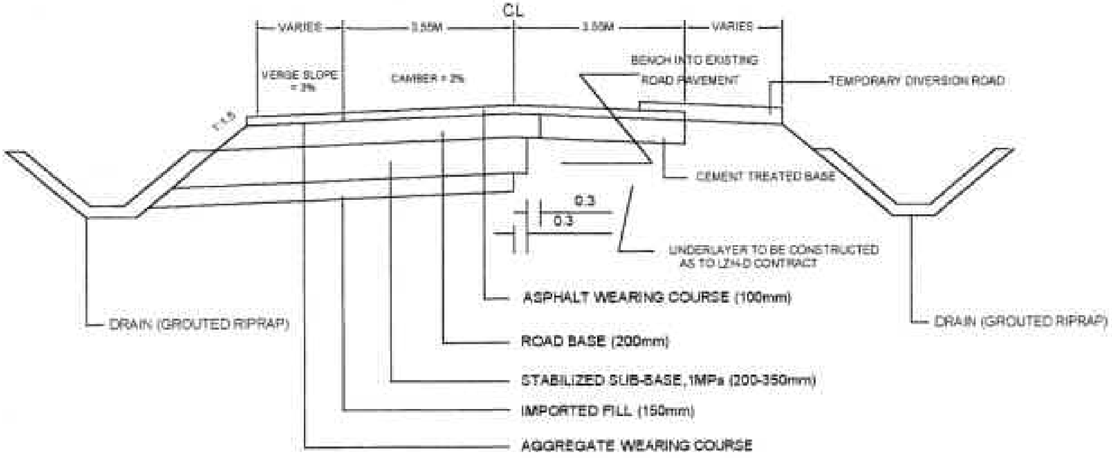
STABILIZED SUB-BASE (SITE B) AT PALICO - BATANGAS CITY ROAD, KM. 142+340 TO KM. 142+700, BAUAN,BATANGAS



SECTION 3: SECTION LIMIT, KM. 142+520 - KM. 142+600

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS BUREAU OF RESEARCH AND STANDARDS	PREPARED & SUBMITTED BY	CHECKED BY	REVIEWED BY	RECOMMENDING APPROVAL	APPROVED BY
	D.D. ALMARIO, PROJ. MGR. E. C. DE LUNA CONSTRUCTION CORP.	LORETO S. CANTORNA	REYNALDO P. FAUSTINO	JUDY F. SESE	ANTONIO V. MOLANO JR.
		PROJECT ENGINEER,BRS DATE	ENGINEER IV,BRS DATE	OIC, ASST. BUREAU DIRECTOR, BRS DATE	BUREAU DIRECTOR,BRS DATE

STABILIZED SUB-BASE (SITE B) AT PALICO - BATANGAS CITY ROAD, KM. 142+340 TO KM. 142+700, BAUAN,BATANGAS



SECTION 4: SECTION LIMIT, KM. 142+600 - KM. 142+700

	PREPARED & SUBMITTED BY	CHECKED BY	REVIEWED BY	RECOMMENDING APPROVAL	APPROVED BY
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS BUREAU OF RESEARCH AND STANDARDS	D.D. ALMARIO, PROJ. MGR. E. C. DE LUNA CONSTRUCTION CORP.	LORETO S. CANTORNA PROJECT ENGINEER, BRS DATE	REYNALDO P. FAUSTINO ENGINEER IV, BRS DATE	JUDY F. SESE OIC, ASST.-BUREAU DIRECTOR, BRS DATE	ANTONIO V. MOLANO JR. BUREAU DIRECTOR, BRS DATE