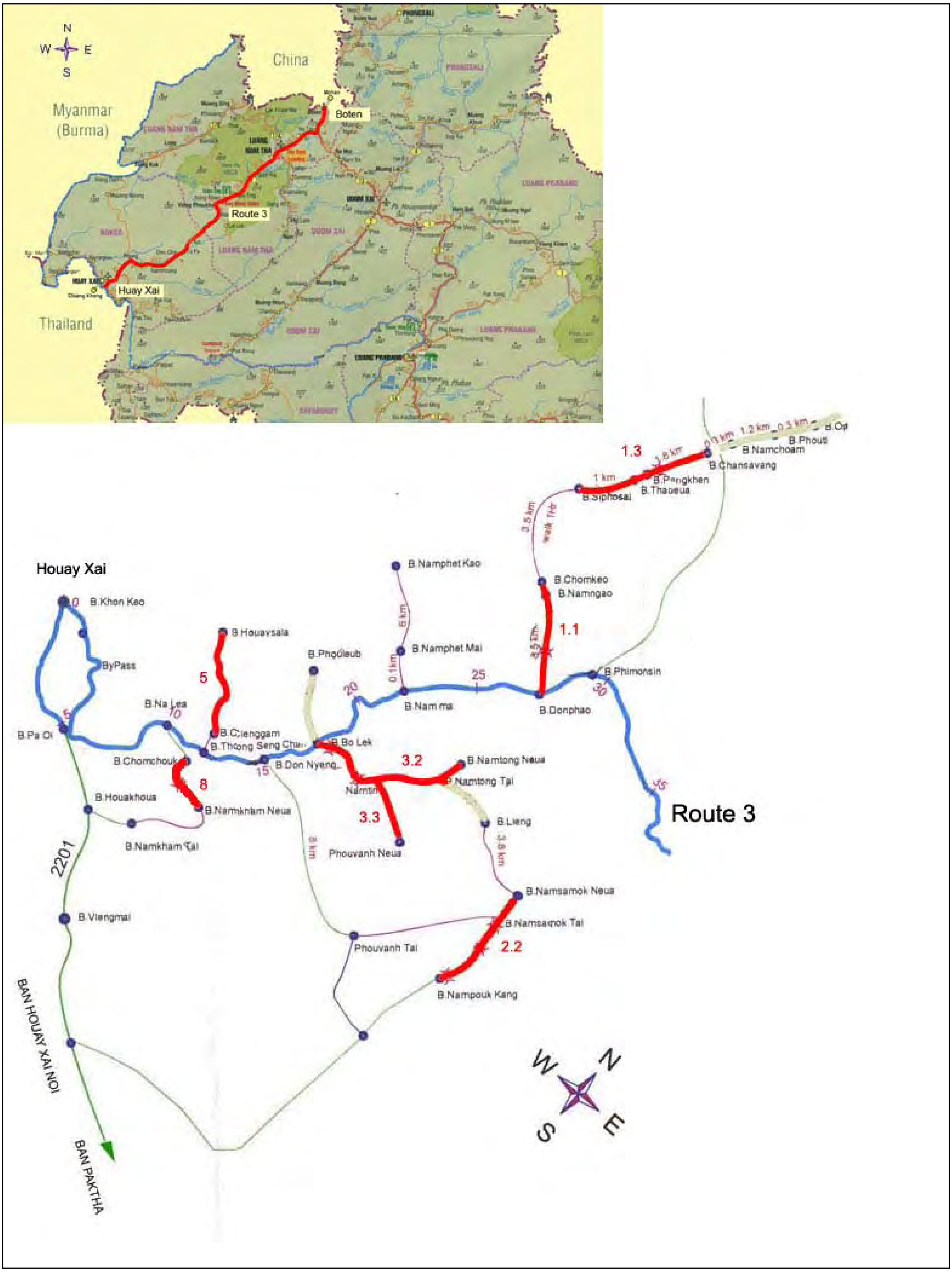
APPENDICES

APPENDIX 1

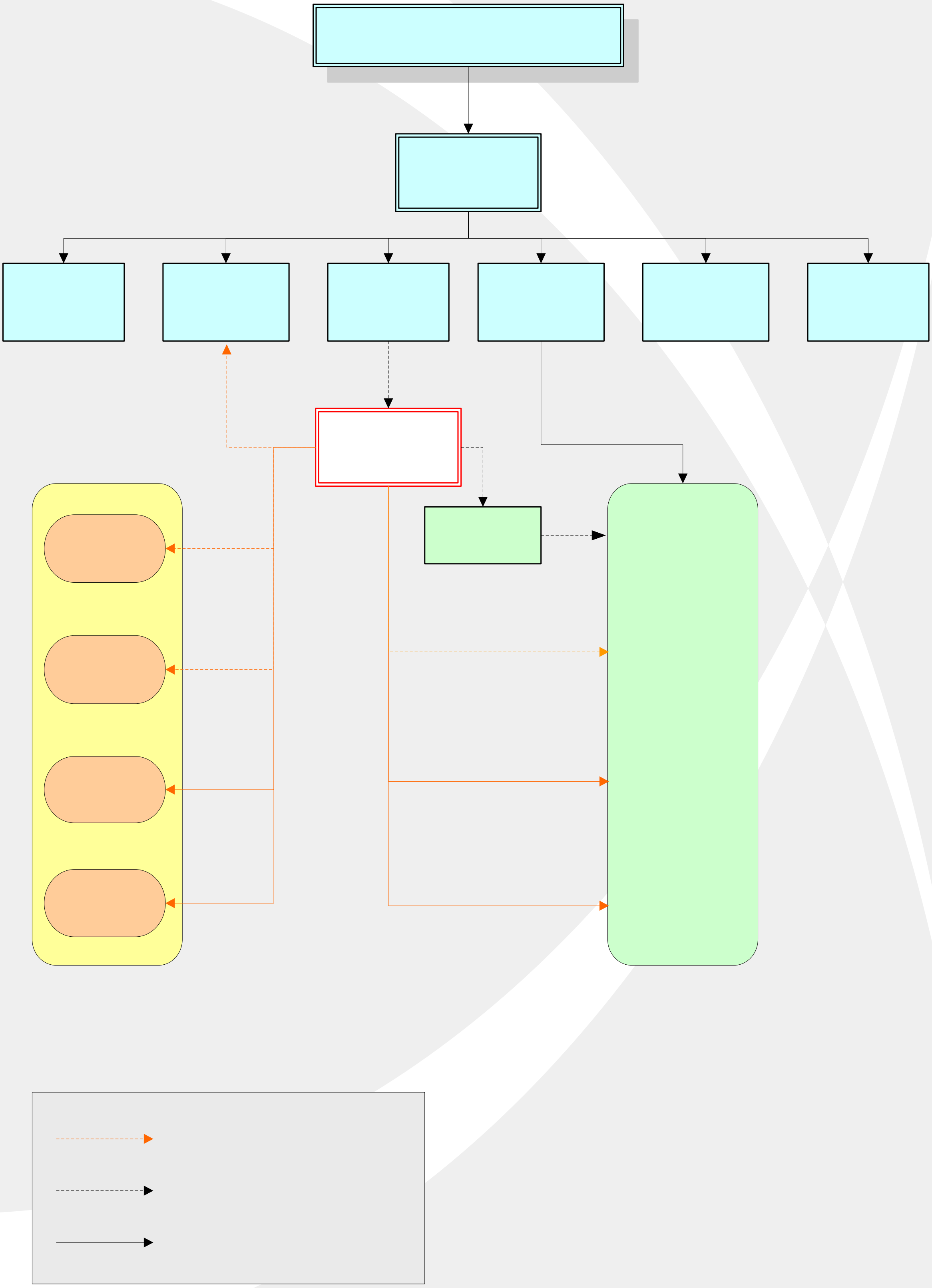
Project Area Map

Project Area Map



Appendix 2

Project Organisation



Appendix 3

Pavement Design Methodology

Pavement Design

The structural design of pavements is required to produce a structurally balanced pavement that will carry traffic in the prevailing environment at an acceptable level of service without major structural distress as cheaply as possible. Pavement design encompasses factors of in-situ subgrade soils, traffic loading, quality of pavement materials, environmental conditions, construction details, time and economics.

Broadly, for the rural access roads of Lao PDR an acceptable level of service might be defined as having a road that remains open to small vehicular traffic (light motor vehicles, 4 wheel drives and motor cycles) and the occasional medium truck (4 to 7 t) all year round. While remaining open all year round it is unacceptable that these rural access roads provide road users with an excessively bumpy and perhaps dangerous journey.

It is vital that the pavement design is accomplished with a high level of confidence that the structure will endure the structural design period. In other words the pavement must be capable of carrying traffic over the full economic analysis period. For low volume rural access roads this can only be accomplished providing a strategy of routine and periodic maintenance is applied to the road (TRH 4, 1996[14]).

It is important to note that any pavement design procedure can only make an estimate of the timing and nature of the maintenance measures that may be required. The actual maintenance should be determined by proper maintenance procedures. The accuracy of the prediction can almost certainly be improved by having a feedback system.

The present worth of costs of alternative designs should be calculated over the full analysis period using an estimate of the rehabilitation and salvage value, and the most economical pavement structure chosen. It is common that rural access roads are designed for a period of between 10 and 20 years.

A rural access road can be defined as a road that connects small settlements for villages in rural areas to a significant arterial road which in turn connects small towns to one another. Often, these villages are only connected by a small track or footpath which allows only hardy 4 wheel drive vehicles access for some of the year (usually in the dry season). The purpose of a rural access road is to provide reliable year round access to a greater range of vehicles.

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[14] ***Structural Design of Flexible Pavement for Interurban and Rural Road (TRH 4 1996),*** *Committee of State Road Authorities, CSIR, Pretoria, South Africa, 1996.*

Lao PDR Geography including the Project Area

Lao PDR is a landlocked country that stretches more than 1,700 km from north to south and between 100 to 400 km from east to west. The country is bordered on the south by Cambodia, and on the north by China and Myanmar. The Mekong River forms the country's western border with Thailand and the Annamite mountains form its eastern border with Vietnam. The total land area is approximately 237,000 km^2.

Topography

Some 75% of the country is hilly to mountainous. In the north and northeast, elevations of 1,000 to 1,500 m are not uncommon. The rest of the country consists of flat to gently undulating lowland and alluvial plains and terraces adjacent to the Mekong River at an elevation of 250-300 m. The north of Lao PDR (project area) is made of steep sloped mountain ranges with the highest mountain in the country at 2,820m in Xiang Khouang province.

The project area is thus expected to contain varied gradients since they will traverse hilly to mountainous terrain. This has been determined from the topographic survey and the alignment design as conducted by the NEC consultant.

Based on the work conducted under SEACAP 4, described above, it is recommended that rural assess roads with gradients of 4% or greater are not surfaced using gravel. Therefore applying this to the centre line levels obtained for the seven roads results in likely problematic sections as shown in Appendix 5. While this does show the potential problematic areas it is necessary to verify this during a detailed field visit.

Road Foundation (In-situ Subgrade Quality)

The road foundation is classified by bearing capacity of the in-situ material at a specific density and moisture content. The bearing capacity is commonly measured by Californian Bearing Ratio (CBR) determined in the laboratory on samples of material taken from the site. The samples are compacted to some predefined density (often 95% of maximum dray density) and soaked for 4 days in water. CBRs can also be conducted in the field along the road alignment using field test equipment, varying for in-situ CBR apparatus to the more simple Dynamic Cone Penetrometer (DCP) apparatus.

Obviously, the in-situ subgrade strengths of the material on which the road is to be constructed will vary along the length of the road. It is necessary, therefore, by importing Selected Subgrade (SSG) material to construct a capping layer on the in-situ material of varying thickness, depending on the bearing capacity of the in-situ material, in order to compensate for the variation in bearing capacity along the road. Pavement design methods compensate for these weaker areas by applying selected subgrade (capping) layers below the pavement structure.

Delineation of In-Situ Subgrade Areas

In order to undertake an optimal pavement design the road should he subdivided into similar subgrade areas. While, too finer delineation may lead to confusion during construction it is desirable to located three broad categories:

Table 1 Definition of Subgrade

➢ Problematic Areas	These are areas where the gradients are steep and the surface suffers from sever erosion during the wet season. Also, flat low swampy areas where the subgrades are poor quality and vehicles get bogged down during the wet season.
➢ Good Areas	These are areas where the in-situ material is found to have a good bearing capacity and with some drainage correction the road would be passable through out the year. In general, these areas are expected to along undulating terrain with good drainage where the application of an engineered pavement or even a surface will have little benefit.
➢ Potentially Poor Areas	These lengths are those lengths of the road that are almost always passable throughout the year. However, during severely wet periods these section may be problematic and therefore they would benefit from a low cost surface being applied. These sections are typically those low lying areas prone to occasional flooding or areas that pass through low quality materials that have severely reduced strength when wet.

Therefore, clearly there are three critical items that need to be determined along the proposed route of the access road:

- ➢ Topography (Vertical and Horizontal Alignment),
- ➢ Drainage, and;
- ➢ Subgrade Condition.

It is also important to consider geology, topography and drainage or major soil boundaries so that an appropriate design bearing capacity is defined for each in-situ subgrade unit. In order to properly design a road some soil survey should be conducted along the length of the road alignment to define the design subgrade bearing capacity. It is recommended that the 'material depth' to which the subgrade bearing capacity is defined for rural access roads is 700 mm.

Further, it is necessary that the designer differentiate between localised appropriate or poor in-situ soils and more general in-situ subgrade areas. Localised soil should be treated separately from the rest of the pavement design. Often, localised poor soils will be removed and replaced with suitable material.

During the detailed visual condition survey of the road these aspects should be assessed carefully and discreet lengths (50-100 m, say) should be rated as poor, fair, good. While it is possible for an experienced engineer to visually assess the subgrade quality it is often conducted by sampling and laboratory testing the material and supplementing these results with more convenient DCP tests.

Design Bearing Capacity (CBR) of the In-Situ Subgrade

The aim of the pavement design process is to protect, use and improve the bearing capacity of the in-situ subgrade material so that the pavement will be able to fulfil the service objective for the design life of the road, which for rural roads is expected to be 10 years. The bearing capacity of the subgrade is improved by overlaying it with only the necessary (and appropriate) layers of material to achieve an integrated structurally balanced pavement system.

The laboratory CBR is normally determined after the specimens have been soaked for four days prior to testing. For this work the subgrade design classes are limited to four, see **Error! Reference source not found.**, note that at a single point this is the minimum bearing capacity over the material depth (700 mm) Special measures are necessary if a material is identified as Class SG4 (CBR <3%), these include stabilisation (chemical or mechanical) and the removal or addition of extra cover.

Design CBR on Fill

When the road is constructed on fill, the designer must use the best information available on the local materials that are likely to be used. The bearing capacity material must be assessed to the material depth (700 mm).

Design CBR in Cut

The design CBR of the road bed in a cut should be taken as the lowest realistic CBR encountered within the material depth (700 mm).

Selected Subgrade Layers

TRH 4[15] has a well tested method of undertaking the improvement of weaker subgrades by applying selected subgrade layers and this method is applied during this design. The TRH 4 method assumes that all subgrades are brought to an equal support standard which is defined as Type G9 material for rural access roads, the properties for Type G9 material is

[15] ***Structural Design of Flexible Pavements for Interurban and Rural Roads**, Technical Recommendations for Highways (TRH 4), Committee of State Road Authorities, CSIR, Pretoria, South Africa, 1996*

shown in **Error! Reference source not found.**, together with those for Type G7, Type G8 and Type G10.

Table 17 Material Properties for Classified Material (TRH 4)

Material Class	Type G7	Type G8	Type G9	Type G10
Minimum CBR (%)	15	10	7	3
Plasticity Index (%)	<12	<12	<12	Not required
Max.Swell (%)	1.5	1.5	1.5	Not required
Max.Size (mm)	2/3 layer thickness	2/3 layer thickness	2/3 layer thickness	2/3 layer thickness

Normally, the in-situ subgrade soil will be prepared through proof rolling of ripped and recompacted in-situ material to a depth of 150 mm below the top of subgrade. On top of this prepared layer a selected subgrade layer may be placed in order to improve poor in-situ subgrades. The application of this layer and its thickness will vary according to the design CBR of the subgrade. **Error! Reference source not found.** shows the recommended preparation of the subgrade and the required selected subgrade layers in order that the road foundation can be brought up to a standard bearing capacity.

Table 18 Preparation of Subgrade/ Roadbed and Required Selected Layers for Different Subgrade Design Bearing Capacities (TRH 4)

Subgrade CBR Class	SG4	SG3	SG2	SG1
Design CBR of the Subgrade	CBR<3*	3≤CBR<7	7≤CBR<15	CBR≥15
Add Selected Layer	Requires some removal of poor material as specified by the Engineer	150 mm G9 (CBR≥7 PI≤12)	None	None
Treatment of in-situ subgrade		Rip and re-compact to 150 mm G10 (CBR≥3)	Rip and re-compact to 150 mm G9 (CBR≥7 PI≤12)	Rip and re-compact to 150 mm G7 (CBR≥10 PI≤12)

Method of Determining the Subgrade Bearing Capacity

The method of determining the subgrade bearing capacity is to collect representative samples of the subgrade material within the material depth (700 mm) and to conduct 4 day soaked laboratory CBR tests on the samples. To conduct DCP tests at the locations where the CBR samples were taken and conduct a correlation. Look at Emery and define the soaked CBR from DCP results.

Traffic Loading

In order to compare one pavement type against another and to make meaningful conclusions about durability and performance it is essential to construct the pavements trial to withstand the estimated traffic loading over a specific design period. It is taken that the predicted traffic loading on these rural assess road is low. A simple theoretical exercise shows that the estimated traffic loading for four different well known pavement design methods is shown in

Table 19 Estimated Traffic Loading

Description \ Direction	Access Road 1 Base Scenario	Access Road 2 25% of Access Base	Access Road 3 300% of Access Base
Cumulative Design Traffic Loading	0.025	0.020	0.040
Overseas Road Note 31 Traffic Classification	T1	T1	T1
Low Volume Roads Traffic Classification	0.05M	0.05M	0.05M
TRH4 Traffic Classification	ES0.03	ES0.03	ES0.10
IRC SP:20-2002 No.of Com.Vehicles per Day	2	1	7

Rural roads are subjected to significant numbers of haulage trucks. It is apparent that these trucks are heavily overloaded, inducing excessive stresses in most pavements and foundations. In the case of Route 3, this problem is not significant since this highway has low traffic volumes.

While the problem of overloading is being addressed under the WB Road Maintenance Project, the consultant needs to review this issue closely, especially in the context of the solutions being drawn up in the neighbouring countries of Vietnam and Cambodia.

Conclusions

The ORN31 and IRC guidelines are for roads with heavier pavement loading than that predicted for these rural access roads thus there is no change of pavement structure for the sensitivity changes in traffic loading. The remaining two methods do show changes and therefore are better suited design methods for these roads, thus these two methods will be applied for the base situation in Table 19.

For concrete roads, the minimum pavement design standards have been selected since concrete pavements are capable of carrying much greater quantities of traffic than is envisaged on these roads. The design method for Segmental Block Pavements[16] have been applied for all designs using both paving bricks, natural stone surfaces and geo cells. In order to be consistent this pavement design has been used for the concrete pavements.

Geotechnical Slope Stability

The geotechnical features of the road slopes will be considered as an integral part of any pavement solution. Where more geotechnically secure and feasible road alignment is evident in hilly or mountainous areas, these will be discussed and noted for future planning reference.

Drainage

Proper drainage of the road pavement and road slopes at problem sites will be considered as an integral part of the proposed technologies. This will address cross-road drainage of storm water flows as well as drainage problems created by adjacent land-management (e.g. blocking drains to assist irrigation).

The effect of flooding will need to be assessed as part of the studies to ensure that the pavement is maintained above historic levels.

NEC Specification for the Construction of Rural Roads

In the absence of a design report describing the pavement design methodology and subgrade investigation for these roads the following is taken from the General Specifications[17].

Roadway Excavation (Section 203)

Subgrade in Cuts (Clause 203.01.5) states that if the bearing capacity of the top 300 mm of subgrade in the cuts is CBR<5% or does not comply with any of the other requirements of Clause 204.02 paragraph (3), see below, then the material shall be removed to a depth as specified by the Engineer and replaced with material complying with Clause 204.02 paragraph (3) of the Specifications.

Therefore if the in-situ bearing capacity is CBR<5% then it must be replaced by CBR>8%. However, if the CBR≥5% it is satisfactory, therefore the subgrade design bearing capacity should be taken to be CBR=5%.

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[16] ***Structural Design of Segmental Block Pavement for Southern Africa**, Clifford,J.M., National Institute for Transport and Road Research, CSIR, July 1982.*

[17] ***Vol 3 - Part B - General Specifications,** Northern Economic Corridor Project, Rural Access Roads Houay Xai District, Supplementary Construction Package No 1, January 2005.*

Embankments (Section 204)

The permissible material for use in embankments is specified in Clause 204.02, Materials, as follows:

(3) Materials placed in the top 300 mm of embankments shall comply with the following requirements:

➢ Liquid limit	AASHTO T89	maximum 40
➢ Plasticity index	AASHTO T90	maximum 14
➢ CBR (4 days soaked)	AASHTO T193	minimum 8%
➢ Maximum particle size		100 mm

(4) Materials placed more than 300 mm below subgrade elevation shall comply with the following requirements:

➢ Liquid limit	AASHTO T89	maximum 45
➢ Plasticity index	AASHTO T90	maximum 18
➢ CBR (4 days soaked)	AASHTO T193	minimum 5%
➢ Maximum particle size		150 mm

Therefore all embankment areas have a subgrade bearing capacity of CBR>5% with a selected layer of 300 mm thick with a bearing capacity CBR>8%.

Compaction of Earthworks (Section 205)

It is not clear when the subgrade is embankment or when it is earthworks, however it may not be important since the specification requires that requirements of Section 204 are adhered to unless some particular situation is found.

Subbase and Wearing Course (Section 301)

This work is described as furnishing and placing one or more courses of aggregate, including binder soil if required, on a prepared subgrade in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or established by the Engineer.
Based on the NEC standard drawing (Typical Cross Section – TC01.dwg) a single layer of 'gravel wearing course' of 200 mm thickness is specified, thus no subbase is specified on any roads.

The material are specified to consist of uniform mixtures of naturally occurring or processed materials comprising gravel and/ or crushed rock fragments with sand, silt and clay. The material is to be free from dirt, organic matter, shale or other deleterious matter and shall be of such quality that it will bind readily to form a firm, stable course.
The material is to conform to the grading requirements shown in.Table 20

Table 20 Grading Requirements

Sieve (mm) (AASHTO)	Percent Passing (by weight)	
	Type B Wearing Course	**Type A Subbase**
100		
75		
50.0		100
37.5	100	85 – 95
25.0	85 - 100	
19.0	85 - 100	60 – 80
9.5	55 - 100	
4.75	35 - 92	25 – 55
2.0	23 - 77	15 – 35
0.425	14 - 50	7 – 20
0.075	10 - 40	2 – 10

It goes on to state that:

> The gravel wearing course material shall consist of lateritic gravel soil or a mix of gravely lateritic soil and natural river sand/ gravel. The gravel soil and the sand/ gravel shall be materials from selected and accepted sources and be suitable for mixing, as required, to comply with the Specifications.
>
> The sand/ gravel and the soil materials shall be free from contamination by topsoil, vegetation and organic matter and any other deleterious materials of a different nature from the materials required.
>
> The proportions of the different materials to produce the final properties of the gravel wearing course material shall be established by testing and full scale field trials.
>
> Fine aggregate (material passing the 4.75 mm sieve) shall consist of natural or crushed sand.
>
> The various fractions of the material shall have properties according to those shown in Table 21.

Table 21 Material Properties

Property/ Test	Type B Wearing Course	Type A Subbase
Fraction passing 19 mm sieve		
CBR (4 day soaked), @ 95% MDD	Min. 25%	Min. 20%
Coarse Aggregate		
Wet/ Dry Strength Variation	Max. 45%	Max. 45%
Los Angeles Abrasion	Max. 45%	Max. 50%
Fraction passing 0.425 mm sieve		
Liquid Limit	Max. 40%	Max. 35%
Plasticity Index	Min. 8%; Max 20%	Max. 12%
Linear Shrinkage	Max. 5%	

Subbase shall be compacted to 95% of MDD (AASHTO T180 Method D) and the Wearing Course shall be compacted to 98% of MDD (AASHTO T180 Method D).

Conclusion

Taking the subgrade design bearing capacity to be CBR=5%, as discussed above, will satisfy the minimum subgrade conditions, however, for much of the road this may result in an overdesign since the subgrades may exceed the minimum CBR=5%.

The NEC consultants design specified that a single 200 mm layer of gravel wearing course is to be constructed along the length of all rural access roads. Simplistically this material is to have a bearing capacity of CBR≥25% and a Plasticity of 8%≤PI≤20% and a grading as within the envelope shown in Table 20.

SEACAP – 17 Design Concept

While it is possible to construct an all-weather road between two points regardless of the difficult conditions that may be encountered an important constraint is cost, it is not viable to construct a high cost road for a small number of people and thus low traffic volumes when this money could be used for higher priority projects. Therefore it is a challenge for engineers to design cost effective roads, particularly rural access roads such as those identified for this project.

The MCTPC standard for rural access roads or local roads is Class VII and VIII which are aimed at roads with less that 50 passenger car units per day (pcu/d)[18]. The carriageway width can be between 2.5 and 3.0 m, thus a single lane, with unpaved shoulders of between

[18] ***Specification for Local Roads**, Ministry of Communications, Transport, Post and Construction, Department of Roads, Volume 1/04.*

0.25 and 1.25 m wide. However, where the traffic is expected not to exceed 20 pcu/d and when difficult terrain is encountered the carriageway width can be reduced to 2.0 m. The geometric standards for the vertical and horizontal curves are set out in the standard. The crossfall for gravel surfaces is defined to be between 5 and 8% and for surfaced roads between 3 and 4%.

The permissible gradients depend on design speed with a maximum of 12% allowed for a design speed of 15 km/h.

The SEACAP -17 concept is to assess the conditions over which the rural access road is to be constructed in greater detail and to apply different, more appropriate pavement structures to shorter sections of road. It will be well understood that most roads that are impassable are such because of a short problematic section of the road which prevents traffic traversing the entire road. This can be likened to the weak link in a chain which when placed under load causes the chain to break, if the weak link is strengthened then the entire chain is perceived stronger. Therefore the aims of this project are to take relatively sophisticated pavement structures as developed under SEACAP and apply them to identified problematic sections on the selected access roads.

It is accepted that these sophisticated pavements are considerable more expensive that the minimum standard pavement structures for rural access roads, however, it is largely understood that current pavement design practice generally overdesigns the vast majority of the pavement. The common design parameters are to design against the 90th percentile design parameters such as subgrade CBR. This actually means that 90% of the road is overdesigned and that 10% of the road will fail. By splitting the road into shorter sections a higher percentile value can be used which increases the efficiency of this design technique. This is shown schematically in Figure 1.

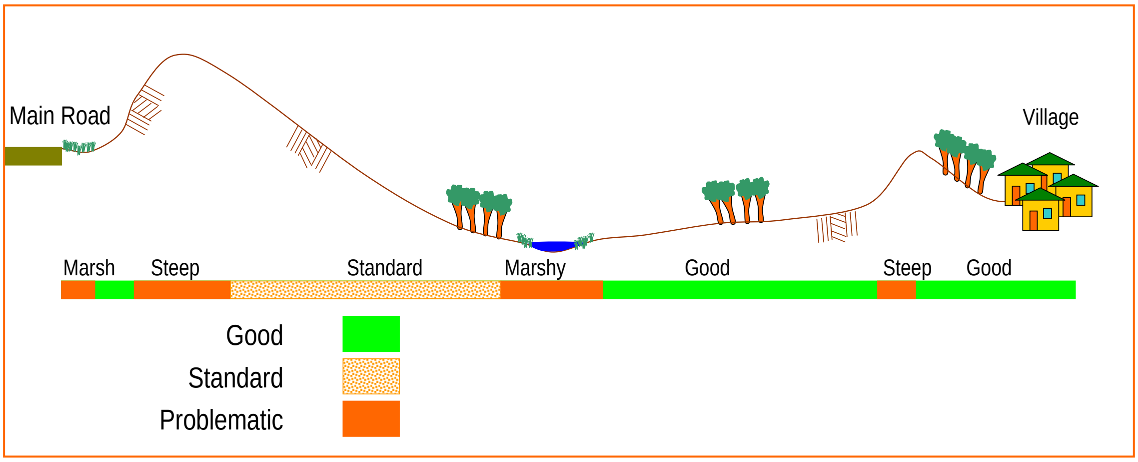


Figure 1 Varying Conditions along an Access Road

Importantly, this approach not only ensures that the problematic lengths are provided with a more robust pavement structure but the good areas are not over designed. In this way it is hope that the condition that the cost of the construction of the access roads is not significantly increased will be adhered to.

Gradient Criteria

The road is divided up along its length according to the following gradient criteria.

Description	Gradient
Flat	>2%
Average	2 – 5%
Steep	>5%

This is based on research in SE Asia which has found the gravel loss on roads on gradients of >4% to be greater than 50 mm per year depending on other factors such as rainfall and traffic. Based on the characteristics of the SEACAP project area, 5% gradient was taken as the criterion for steep sections.

Testing Regime of the In-Situ Subgrade

In order to define the subgrade bearing capacity in terms of the classes listed in **Error! Reference source not found.** some field testing must be conducted along the length of the road alignment. It is obvious that the greater the testing regime the better and more reliable the results that will be obtained and consequently a more reliable pavement design can be undertaken. However, since it is predicted that these rural access roads will carry very little traffic a minimal pavement structure is required. What is important is that the very weak and very strong areas are located, and much of this can be assessed by an experienced engineer and some interaction with the local community.

Pavement Structures

The SEACAP ToR states that the following pavement structures are to be trialled:

1. Cement concrete surface/ natural (or river) gravel base/ red soil sub-base;
2. Cement stabilised in situ soil/ red soil base;
3. Sand-emulsion seal or stone chip emulsion seal macadam surface/ natural (or river) gravel base/ red soil sub-base;
4. Macadam surface/ natural (or river) gravel base/ red soil sub-base;
5. Penetration macadam surface/ natural (or river) gravel base/ red soil sub-base;
6. Mechanically stabilised surface/ red soil base, and;
7. River and/ or natural gravel surface/ red soil base.

Importantly, it is noted that no segmental paving approach is considered in this list and thus an eighth category has been added and the descriptions have been altered to better reflect proper pavement structures.

8. Block Paving on natural gravel subbase.

Following a meeting with Mr.R.Petts of Intech Associates in Vietnam who is involved in the compilation of approximately 20 different pavement structures under the SEACAP programme in Vietnam and Cambodia the following comments on the list of the 7 surface types is made:

Cement concrete surface/ Natural (or river) gravel base/ red soil sub-base.

This option will depend on available aggregates and their suitability for use in concrete. An investigation into using river gravels rather than crushed rock should be undertaken. Options could be Geocell paving, concrete block paving, bamboo reinforced concrete paving, steel reinforced concrete paving and un-reinforced concrete.

Cement stabilized in situ soil/ red soil base.

This will heavily depend on the properties of the in-situ soils. An alternative to cement stabilisation would be to use lime. Stabilised bases often display surface cracks requiring some maintenance. A stabilised soil base must be surfaced in order to protect it since this material would not resist the tractate scour forces of vehicular wheels, a suitable surface would be a bituminous surface such as a double surface dressing or those listed below.

Sand-emulsion seal or stone chip emulsion seal macadam surface/ natural (or river) gravel base/ red soil sub-base.

The first question is whether bitumen emulsion is available and to investigate its advantage over other bitumen types. All bituminous surfaces require aggregate of a certain quality. Some investigation into using crushed rock or natural gravel will be undertaken, particularly the combination sand seals and screened natural aggregate/ crushed river gravel seals. Aggregate haul distances are important.

Macadam surface/ Natural (or river) gravel base/ Red soil sub-base.

As implied above there are a number of surface options that should be considered depending on the quality of aggregate available. The use of an unpaved surface (such as is implied here) depends heavily on the site conditions and availability of materials. Considerable work has been conducted under SEACAP on the appropriateness of gravel surfaces in Vietnam.

Penetration macadam surface/ Natural (or river) gravel base/ Red soil sub-base.

This traditional Asian surface requires good quality crashed aggregate. This is an extremely inefficient use of expensive bitumen which is poured over the aggregate filling the voids in a relatively thick layer. Bitumen application rates for penetration macadam are between 5 and 7 l/m^2 as opposed to surface dressings require less than 2 l/m^2.

Mechanically stabilised surface/ red soil base.

Again this gravel surface may not be appropriate for use in these trials as it will depend on the suitability of local material and the availability of exported material within reasonable haul distances. This too will be covered by SEACAP experience.

River and/or natural gravel surface/ red soil base.

This is presumable, a standard gravel road and its suitability will be checked against the work of SEACAP as described above. Much of the access roads will be constructed using the standard gravel road design methods used in Lao PDR and specified by the NEC Consultant. This pavement and possible some variations of this pavement structure will be monitored during this project.

Other comments relevant to these trials are:

- While SEACAP loosely refers to the trials as different surface types they are in fact pavement structures and as such the pavement structures must be treated as a single entity not just a surface constructed on some material layers. Similarly, the analysis must be conducted on the pavement structure and not just the surface.
- The red soil referred to in the list is taken as the in-situ soil of the project area. It is noted that this material may vary considerably and a more detailed classification will be necessary.
- The choice of pavement structures must be based on use of locally available materials, predicted traffic loading, rainfall and other road environment factors and costs. It is important to assess the risk of overloaded vehicles transporting aggregates, minerals or coal along the trial roads.
- The suitability of gravel surfaces will be influenced by the work being conducted under the SEACAP programme in Vietnam and Cambodia.
- From the available geological mapping, there appear to be few hard rock deposits in the project area, it may, therefore, be necessary to depend on river deposits for durable surface materials.

- Based on our preliminary investigations the in-situ soil may be of a sufficient quality, on some sections of road, that an Engineered Natural Surface (ENS) can be used to replace the standard gravel surface. This strategy may enable saving in the construction costs which may be redeployed to more problematic sections for short sections of road that require high quality surfaces.
- The actual pavement options should be selected from the list that has been drawn up under the SEACAP work in Vietnam and Cambodia. The actual selection must take into consideration the quality of materials found in the project area.
- Regarding the geo-cell paving, it may be possible to fabricate the plastic form material locally from plastic rice sacking material or similar.

Based in our field visits the above points and discussions with MCTPC staff and members of the SEACAP programme the 26 SEACAP pavement structures have been grouped into the 8 categories above. This has resulted in a list of pavement types that are proposed to be trialled under this project (SEACAP 17) and were presented and accepted by all stakeholders at the Initial Project Workshop held in Vientiane in December 2004.

The selected trial pavements are thus:

- Bituminous Pavement (Otta Seal)
- Bamboo Reinforced Concrete Pavement
- Geo Cell Pavement
- Paving Bricks
- Hand Packed Stone(Telford)
- Hand Packed Stone (Mortared Stone)
- NEC Standard Gravel Pavement
- Engineered Natural Surface

Details of each pavement structure and the variations of each are contained in Appendix 6

Material Specifications

For low cost rural access roads it is necessary to defined specifications for natural material that will be sourced locally for the following layers:

- Selected Subgrade
- Natural Gravel Subbase

- Natural Gravel Base
- Cement stabilised Base
- Bituminous Surfaces
- Concrete Surfaces
- Geo Cell Surfaces
- Cement Bricks for Surfaces
- Hand Packed Stone(Telford)
- Hand Packed Stone (Mortared Stone)

Recent work conducted by TRL on low volume sealed roads concluded that the material specifications for these layers can be reduced providing the traffic volumes over the life of the pavement are expected to be low.

The specifications developed for the SEACAP project are given in Appendix 7

Design and Construction of the Structural Pavement Layers (Above the Formation Level)

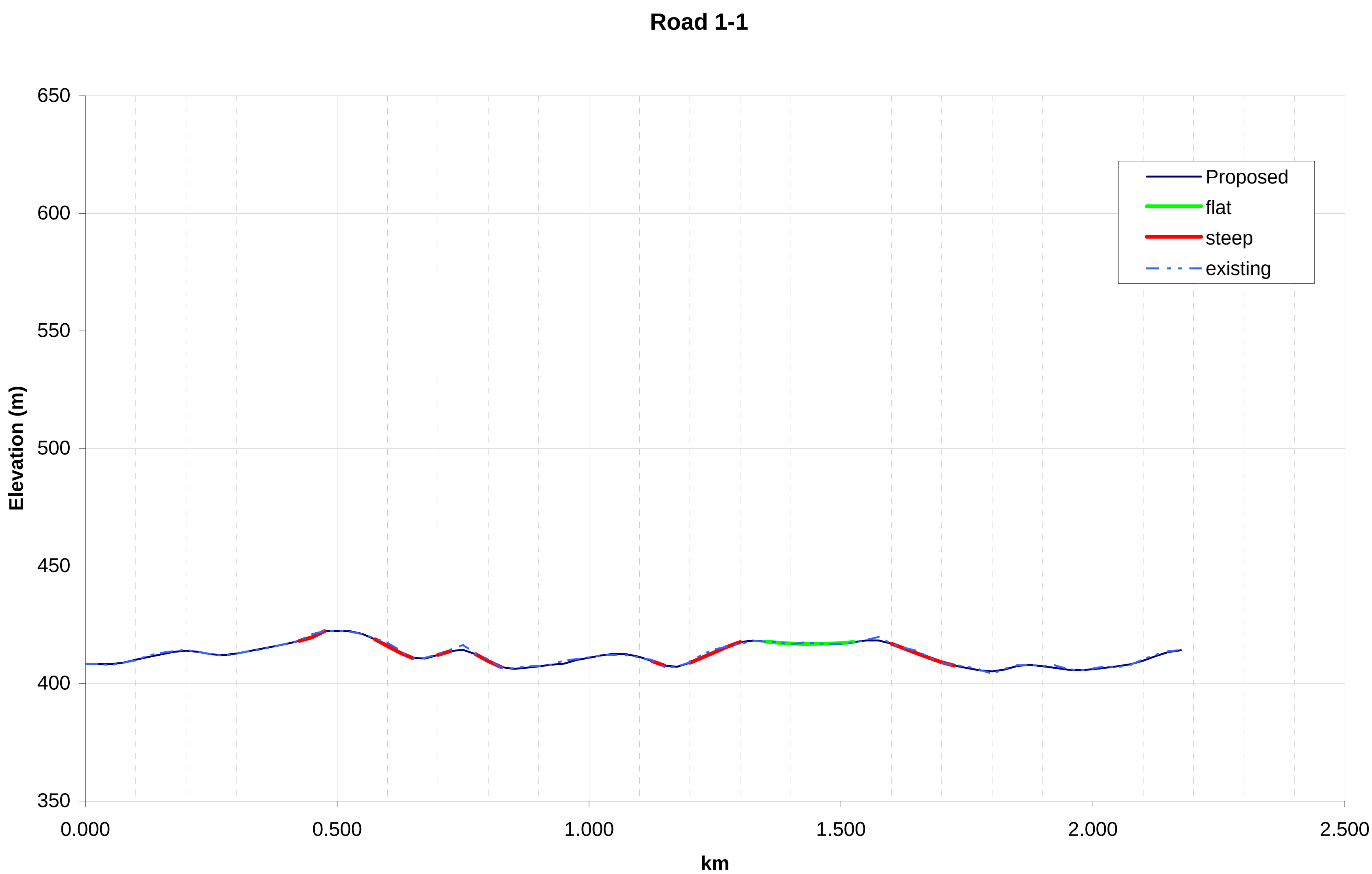
The thickness of the proposed structural pavement layers (base and subbase) should be calculated. The Base layer includes the surface since this is either a non structural layer such as for surface dressings or an integral part of the base for example concrete base layers. The thickness of these layers can be calculated based on a minimum design subgrade bearing capacity of a CBR=7% since the foundation design ensures this. It is possible, however, that the subgrade design bearing capacity exceeds CBR=7% where good in-situ conditions are found.

Design and Construction of the Road Foundation (Up to Formation Level)

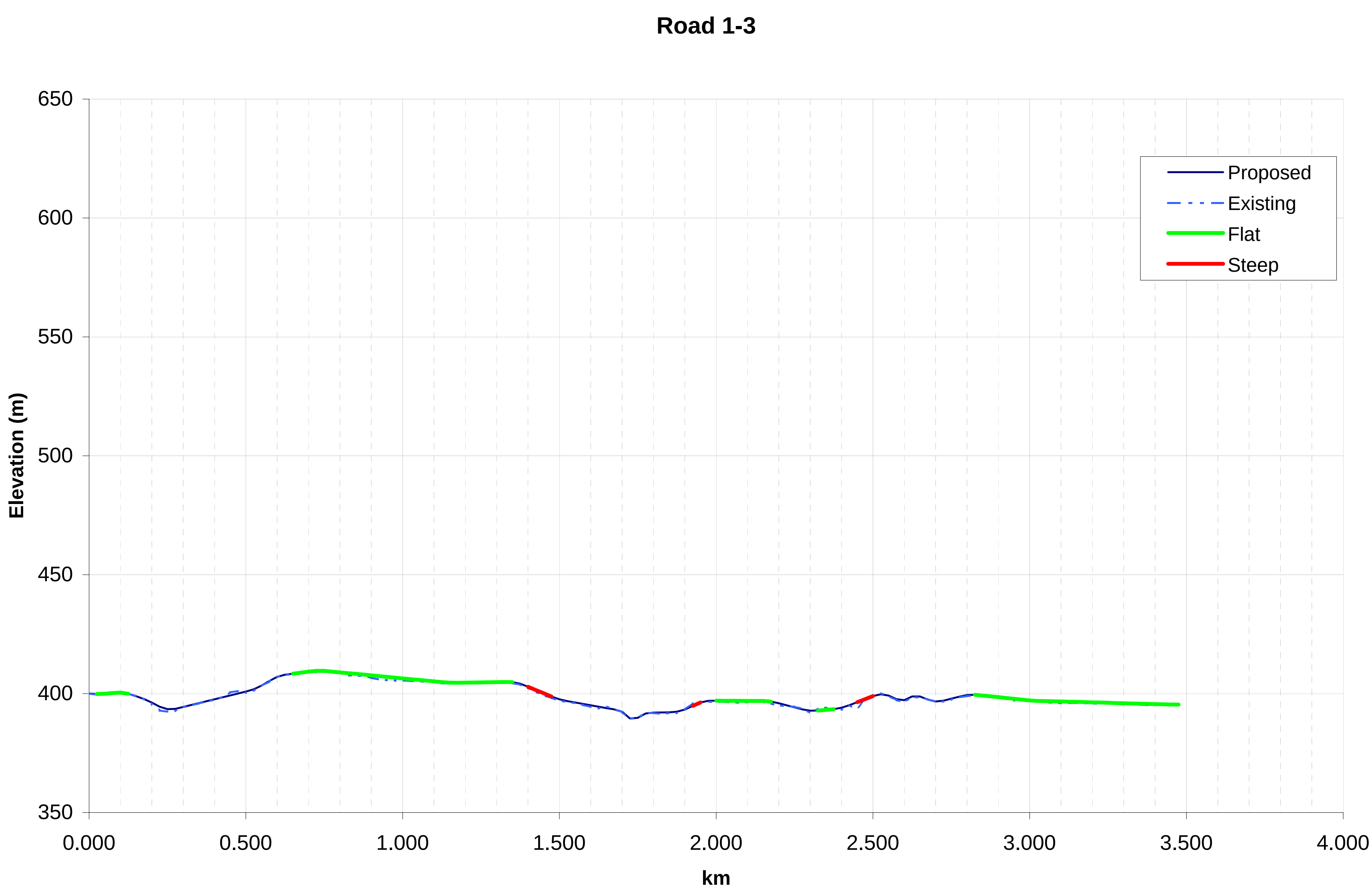
Having established the design subgrade bearing capacity for discrete length of the access road the following pavement construction method should be conducted. The thickness of the proposed structural pavement layers should be calculated. The thickness of these layers can be calculated based on a design subgrade bearing capacity of a minimum CBR=7%

Appendix 4

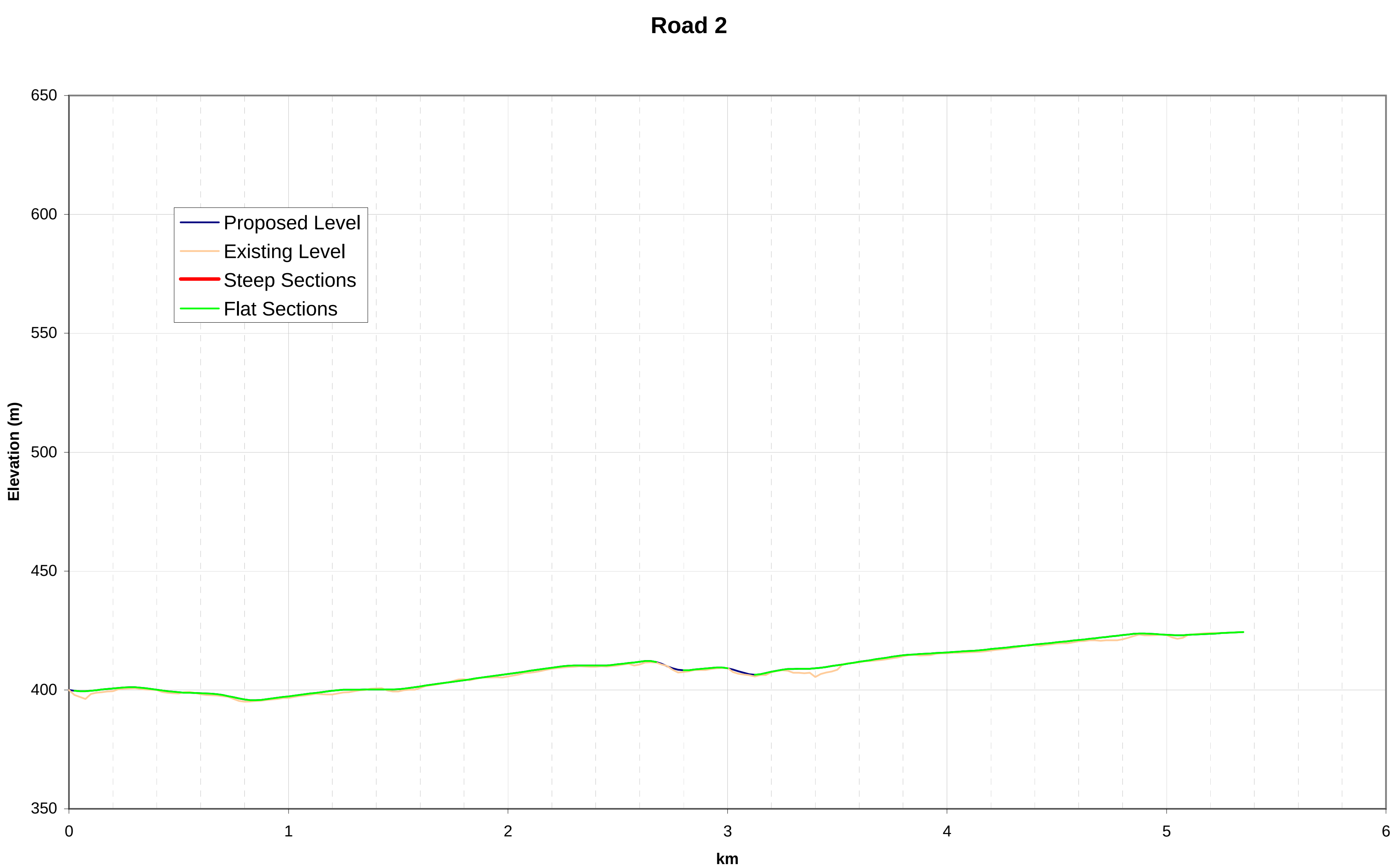
SEACAP Road Profiles

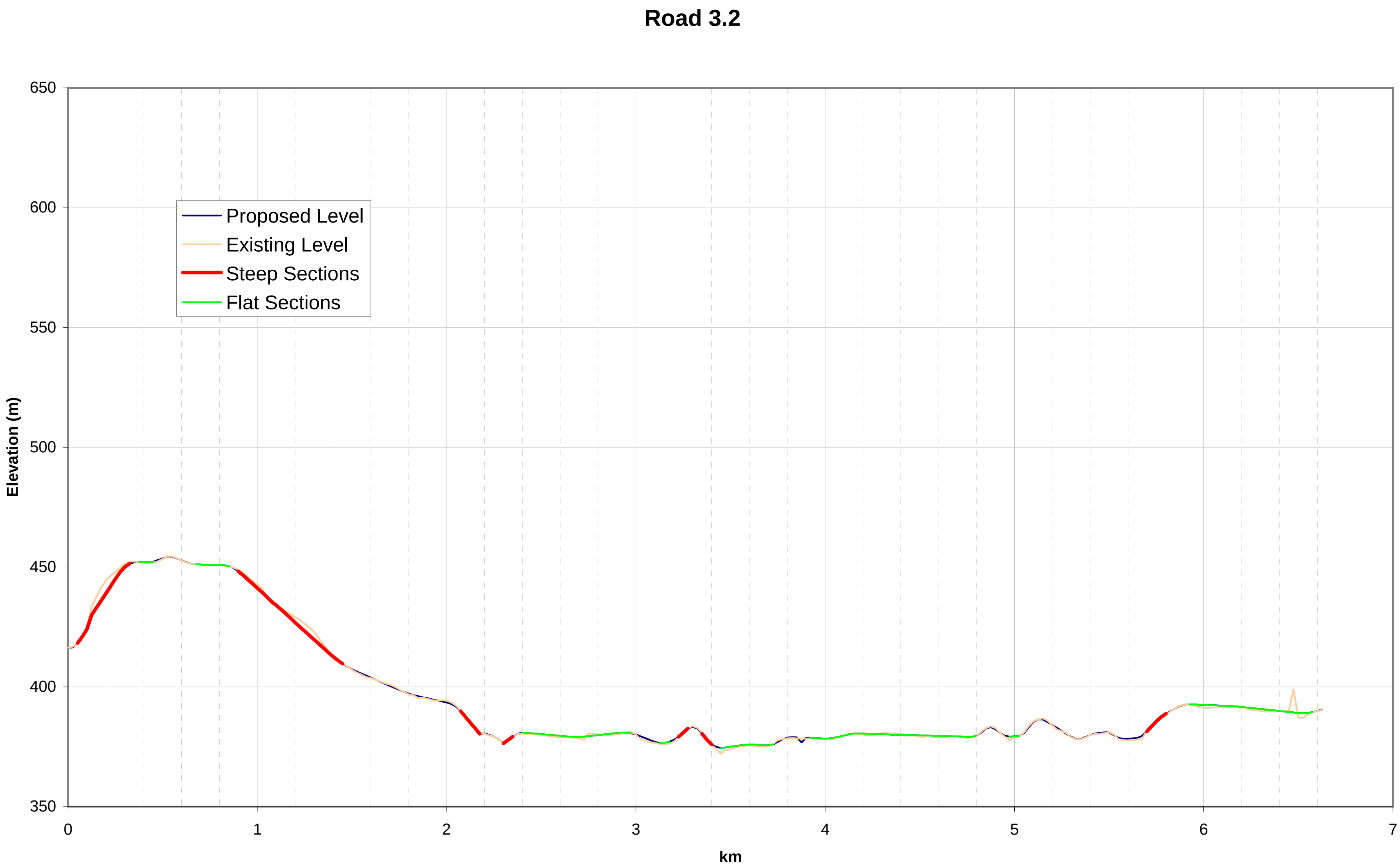


Road 1-1
Elevation (m)
650
600
550
500
450
400
350
0.000
0.500
1.000
1.500
2.000
2.500
km
Proposed
flat
steep
existing



Road 1-3
Elevation (m)
650
600
550
500
450
400
350
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
km
Proposed
Existing
Flat
Steep


Road 2
Proposed Level
Existing Level
Steep Sections
Flat Sections
Elevation (m)
650
600
550
500
450
400
350
0
1
2
3
4
5
6
km


Road 3.2
Proposed Level
Existing Level
Steep Sections
Flat Sections
Elevation (m)
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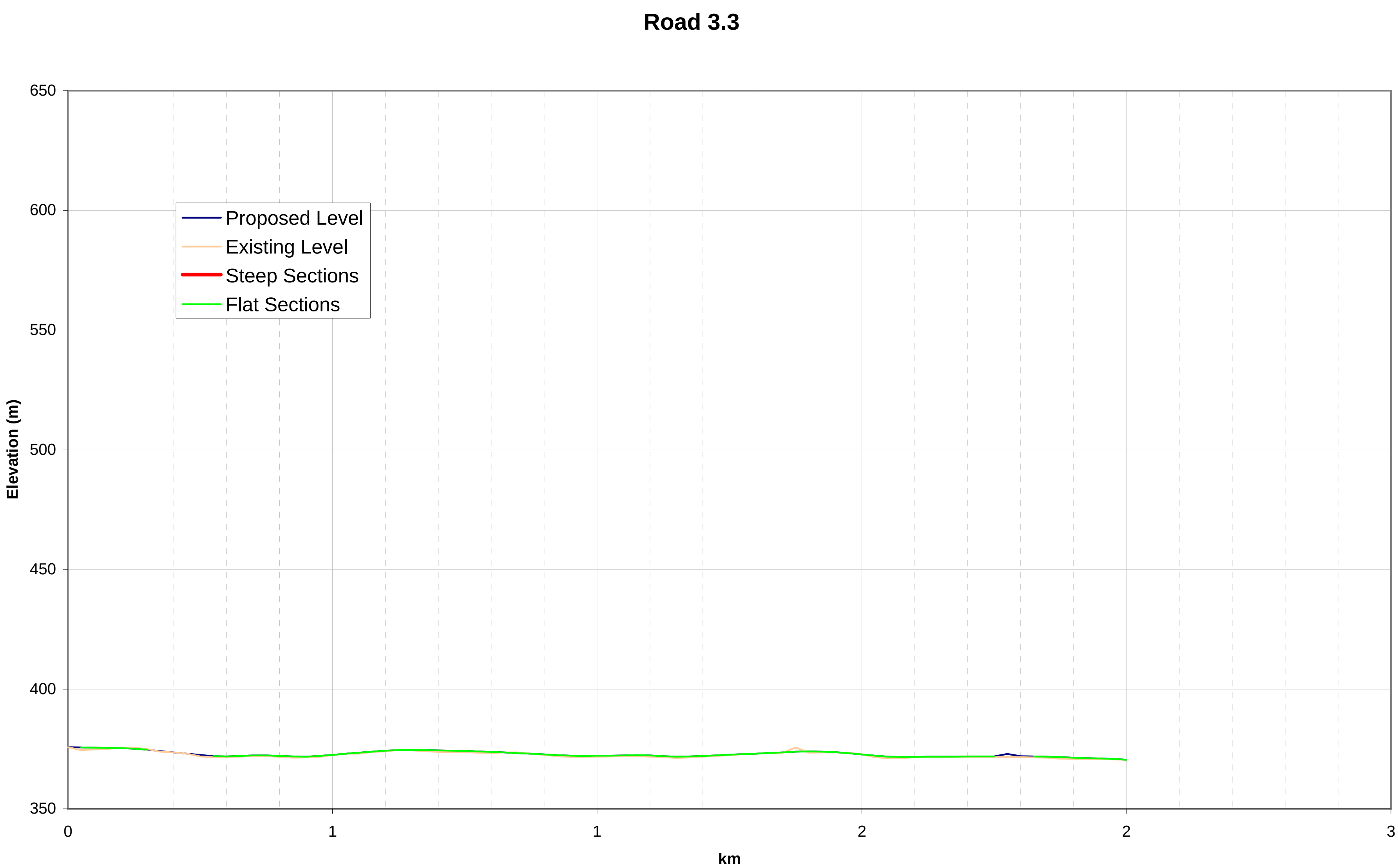
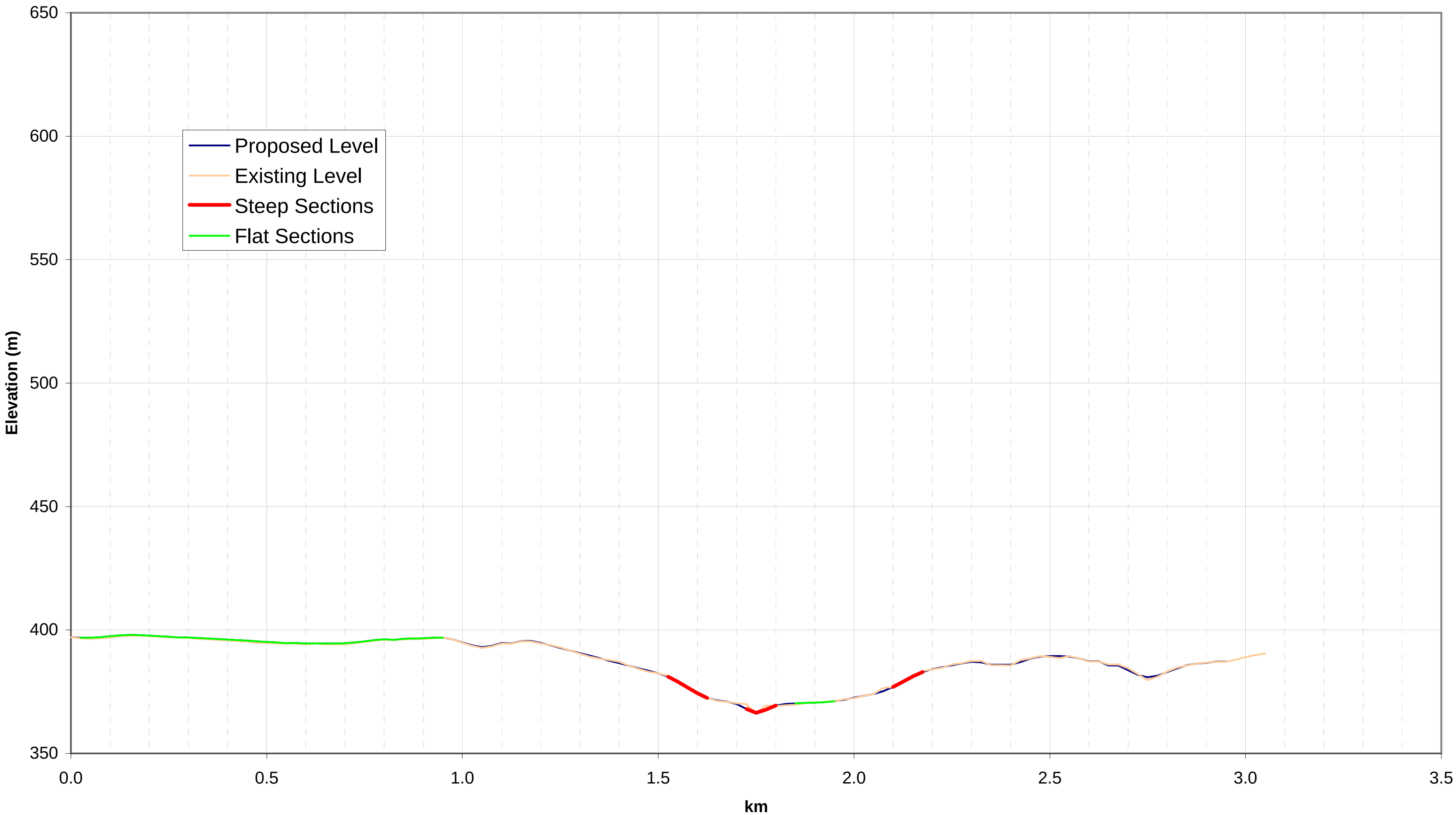
600
550
500
450
400
350
0
1
2
3
4
5
6
7
km


Road 3.3
Elevation (m)
650
600
550
500
450
400
350
0
1
1
2
2
3
km
Proposed Level
Existing Level
Steep Sections
Flat Sections

Road 5
Proposed Level
Existing Level
Steep Sections
Flat Sections
Elevation (m)
650
600
550
500
450
400
350
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
km

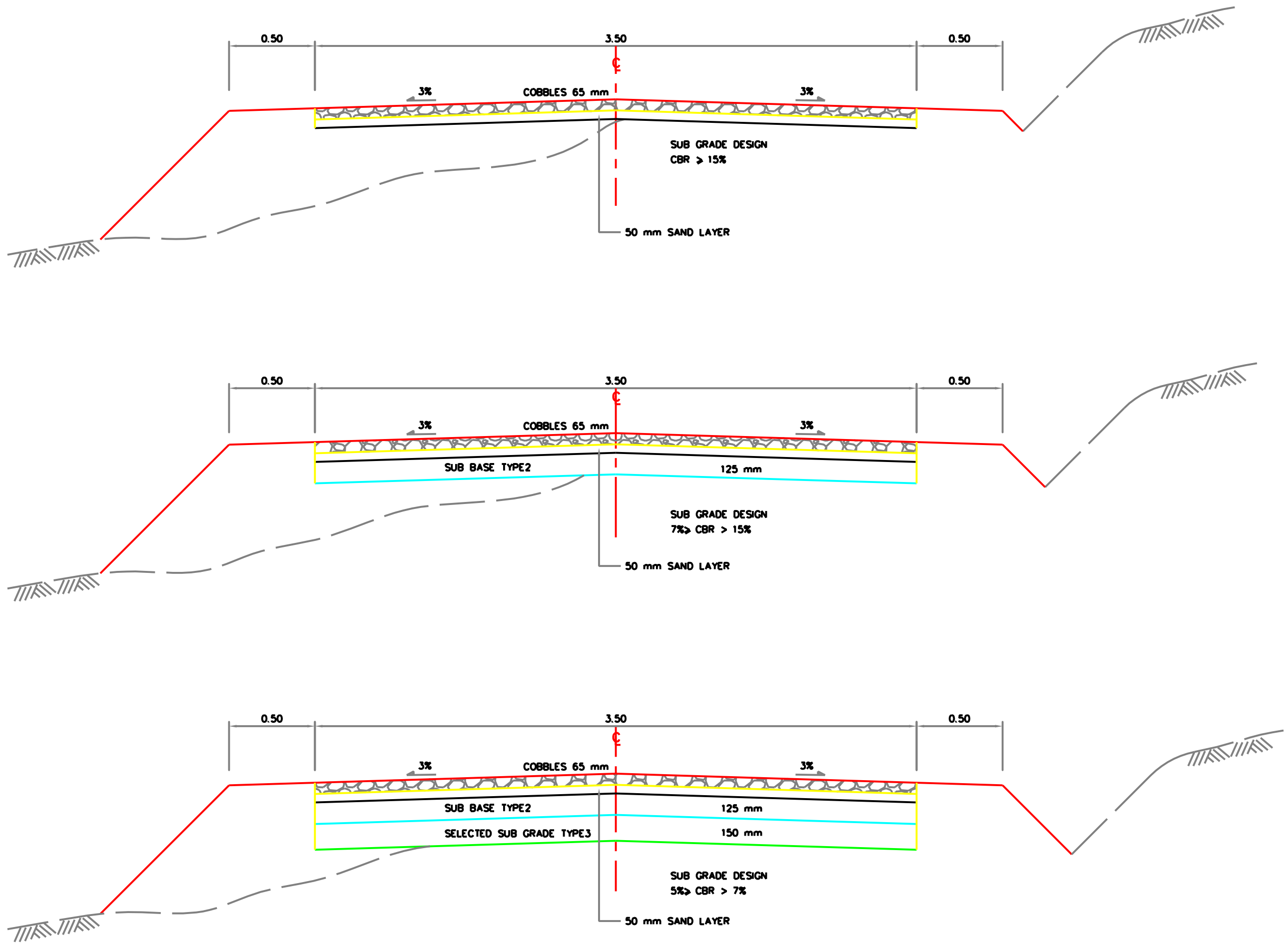
Road 8



Proposed Level
Existing Level
Steep Sections
Flat Sections
Elevation (m)
650
600
550
500
450
400
350
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
km

Appendix 5

Trial Pavement Structures



REVISIONS

No.	Description	Approved	Date

LAO PEOPLE'S DEMOCRATIC REPUBLIC

MINISTRY OF COMMUNICATION TRANSPORT POST AND CONSTRUCTION

NORTHERN ECONOMIC CORRIDOR (R3) ADB LOAN No. 1989(SF)

ACCESS ROAD PACKAGE 1

HOUAY XAI DISTRICT

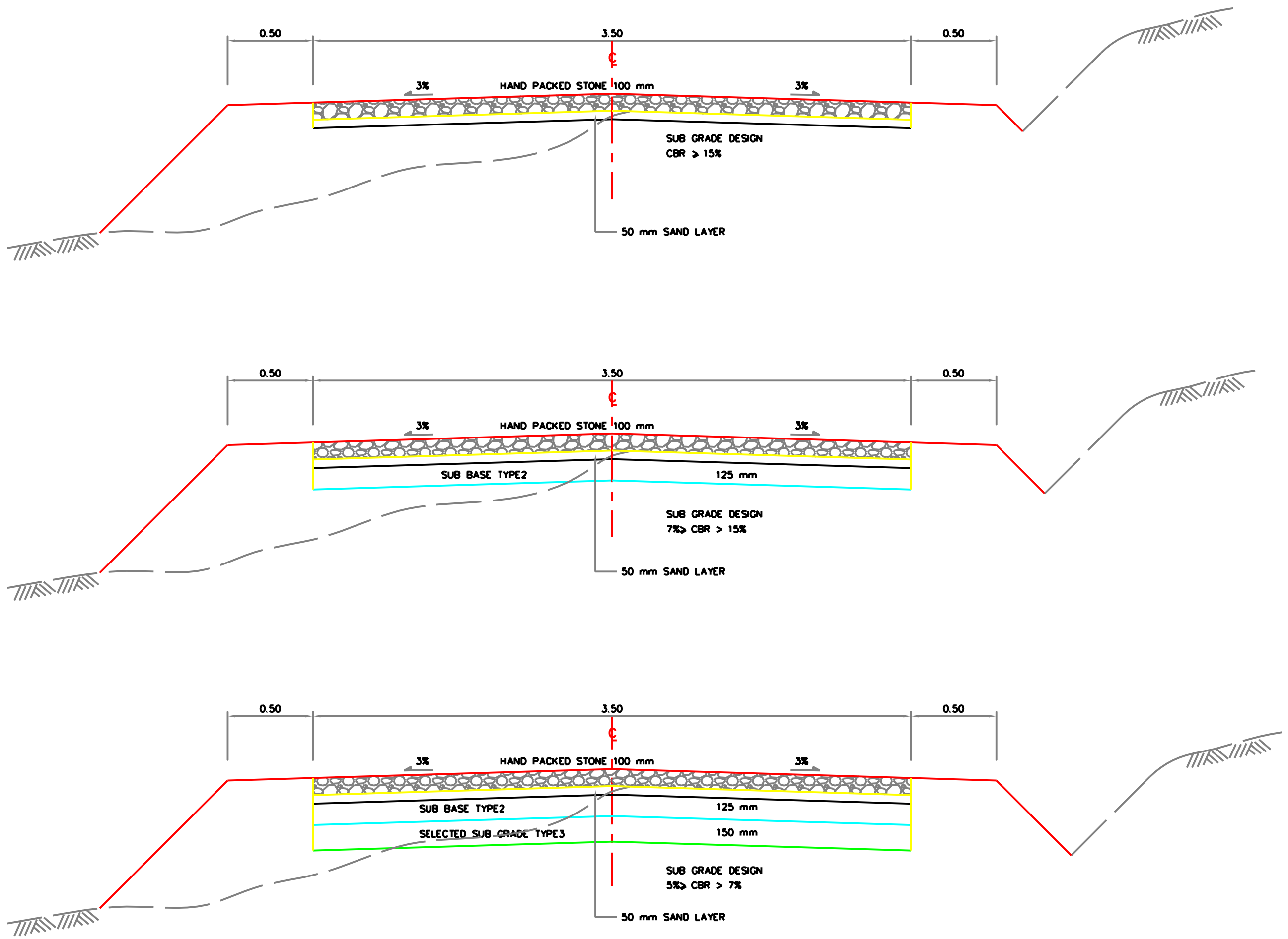
Drawing Title:

MORTARED STONE PAVEMENT

Consultant:

Drawn by :	Date:
Checked by :	Date:
Approved by :	Date:

Scale		Drawing No.	Revision
Vertical:	1:25	SP-07	
Horizontal:	1:25		



REVISIONS			
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MINISTRY OF COMMUNICATION TRANSPORT POST AND CONSTRUCTION

NORTHERN ECONOMIC CORRIDOR (R3) ADB LOAN No. 1989(SF)

ACCESS ROAD PACKAGE 1

HOUAY XAI DISTRICT

Drawing Title:

HAND PACKED STONE PAVEMENT

Consultant:	Drawn by :	Date:
	Checked by :	Date:
	Approved by :	Date:

Scale		Drawing No.	Revision
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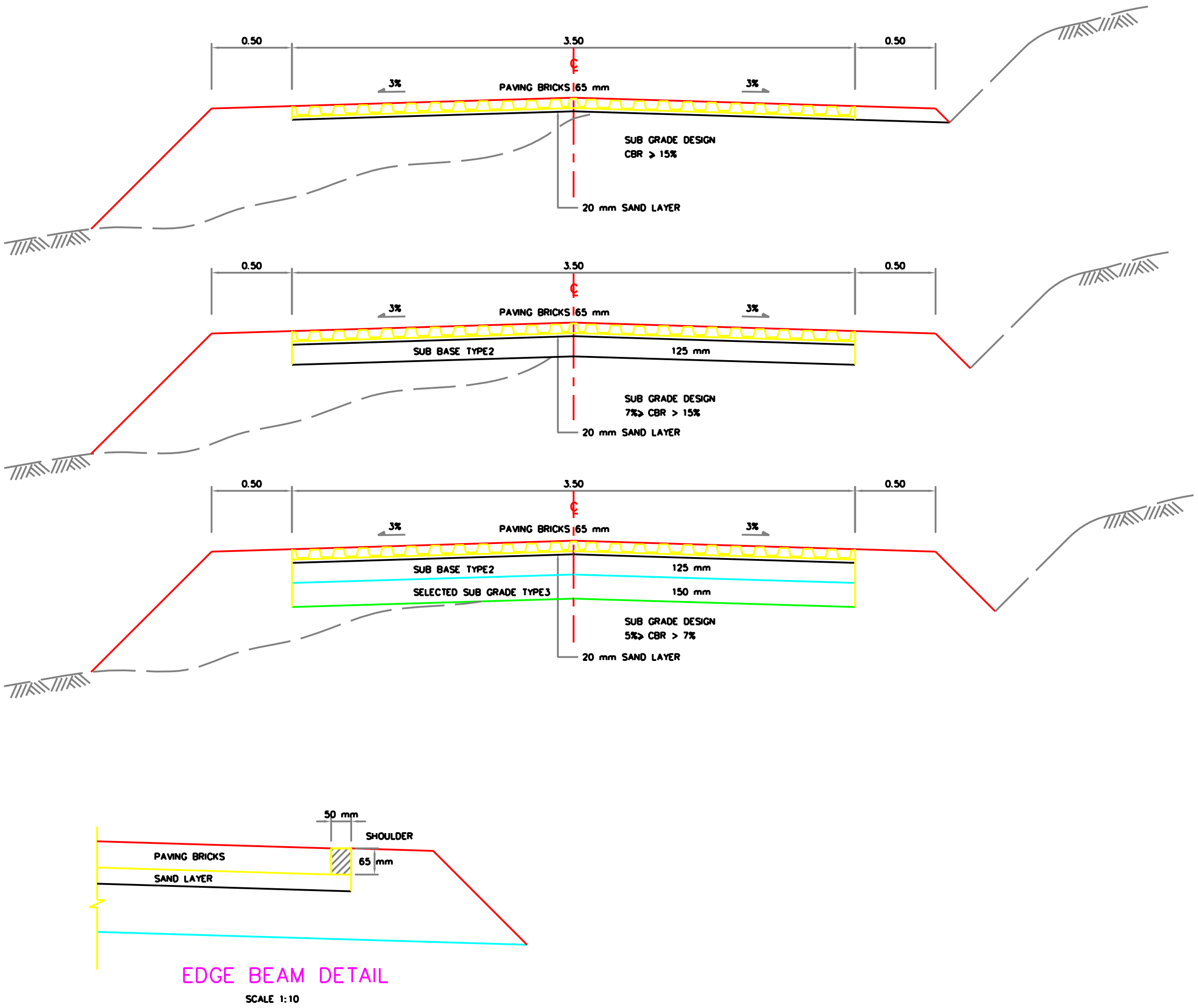
Horizontal:	1:25		



REVISIONS			
No.	Description	Approved	Date

LAO PEOPLE'S DEMOCRATIC REPUBLIC

MINISTRY OF COMMUNICATION TRANSPORT POST AND CONSTRUCTION

NORTHERN ECONOMIC CORRIDOR (R3) ADB LOAN No. 1989(SF)

ACCESS ROAD PACKAGE 1

HOUAY XAI DISTRICT

Drawing Title:

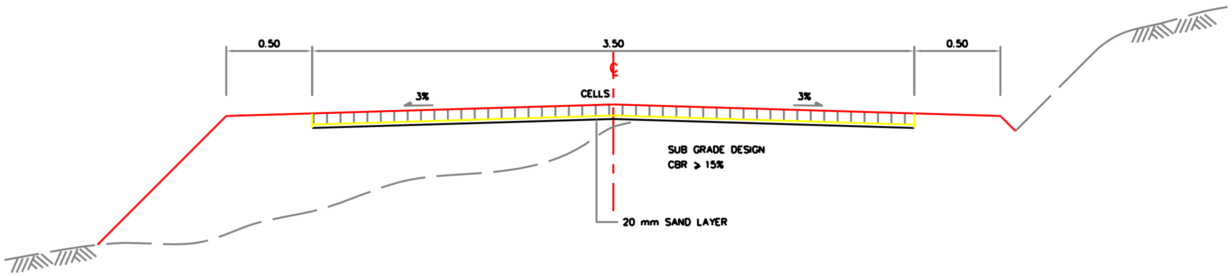
PAVING BRICK PAVEMENT

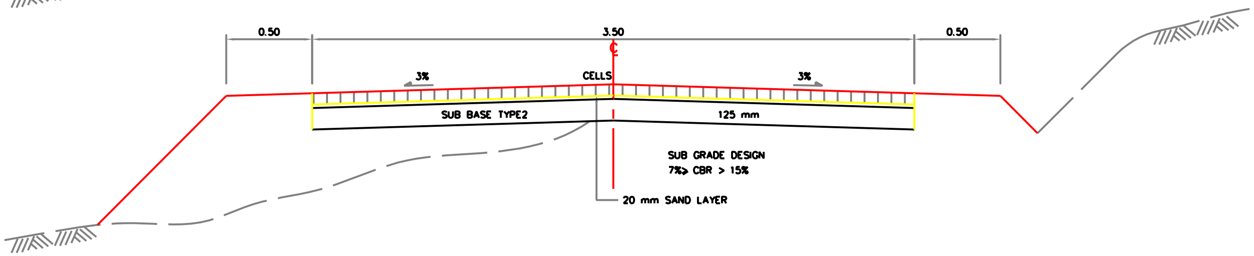
Consultant:

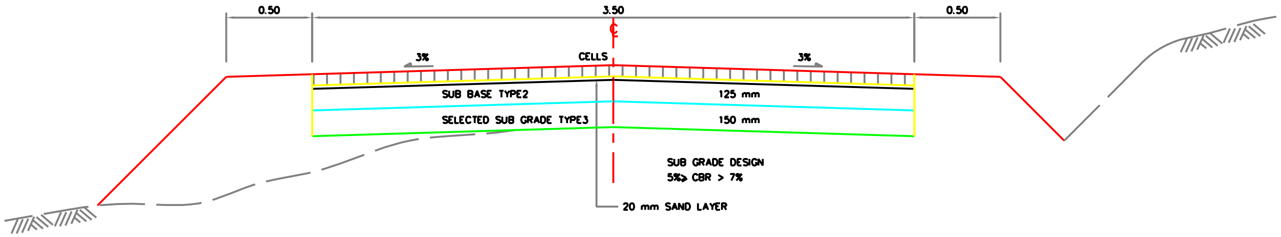
Drawn by :
Checked by :
Approved by :

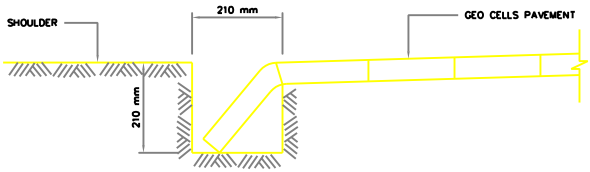
Date:
Date:
Date:

Scale		Drawing No.	Revision
Vertical:	1:25	SP-05	
Horizontal:	1:25		









EDGE BEAM DETAIL

SCALE 1:10

OPTIONS:

GEOCELLS SLAB THICKNESS
75 mm.
100 mm.
150 mm.

REVISIONS			
No.	Description	Approved	Date

LAO PEOPLE'S DEMOCRATIC REPUBLIC

MINISTRY OF COMMUNICATION TRANSPORT POST AND CONSTRUCTION

NORTHERN ECONOMIC CORRIDOR (R3) ADB LOAN No. 1989(SF)

ACCESS ROAD PACKAGE 1

HOUAY XAI DISTRICT

Drawing Title:

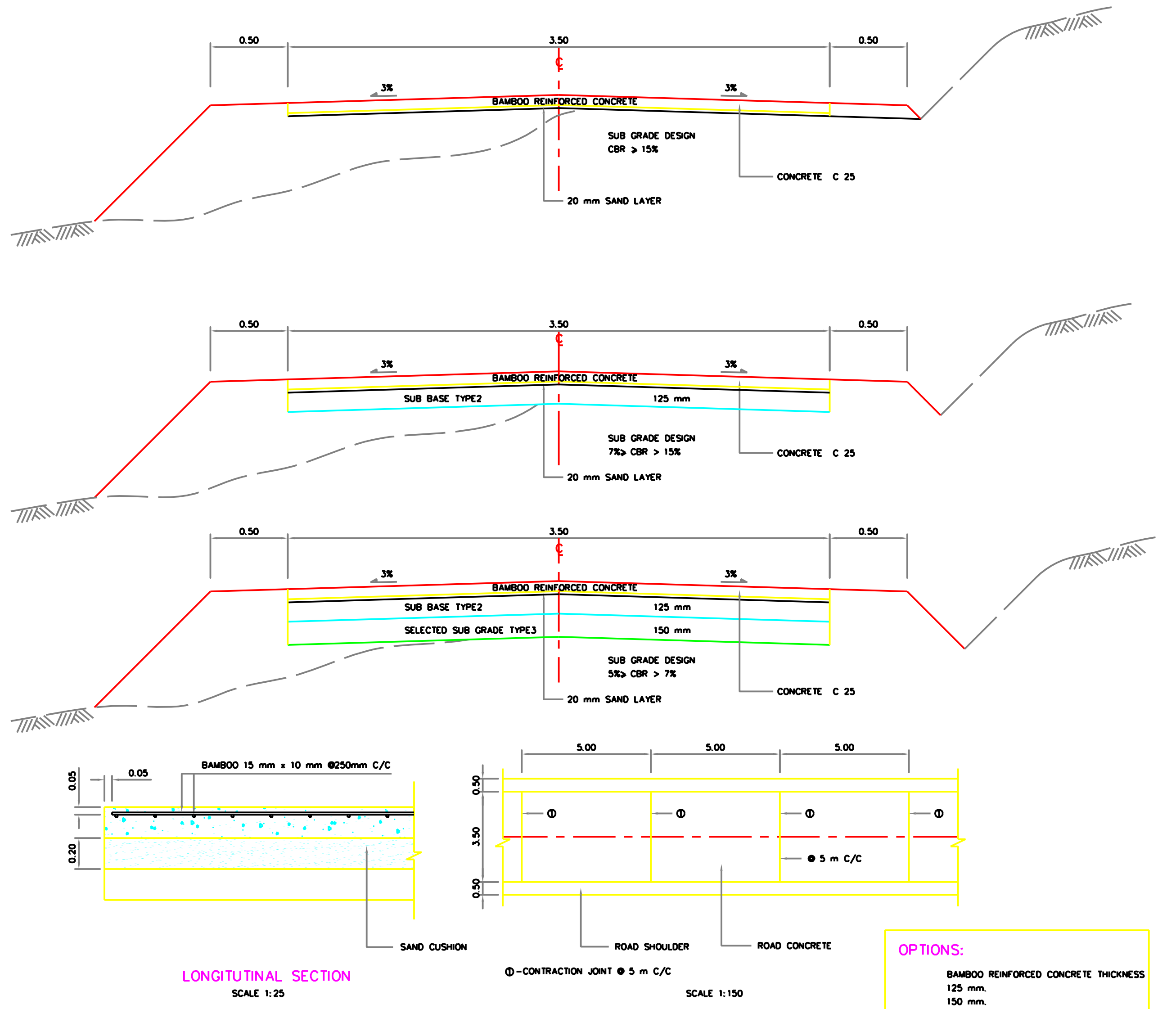
GEOCELL PAVEMENT

Consultant:

Drawn by :
Checked by :
Approved by :

Date:
Date:
Date:

Scale		Drawing No.	Revision
Vertical:	1:25	SP-04	
Horizontal:	1:25		



OPTIONS:

BAMBOO REINFORCED CONCRETE THICKNESS
125 mm.
150 mm.

REVISIONS			
No.	Description	Approved	Date

LAO PEOPLE'S DEMOCRATIC REPUBLIC
MINISTRY OF COMMUNICATION TRANSPORT POST AND CONSTRUCTION
NORTHERN ECONOMIC CORRIDOR (R3) ADB LOAN No. 1989(SF)

ACCESS ROAD PACKAGE 1
HOUAY XAI DISTRICT

Drawing Title:
BAMBOO REINFORCED CONCRETE PAVEMENT

Consultant:

Drawn by :	Date:
Checked by :	Date:
Approved by :	Date:

Scale		Drawing No.	Revision
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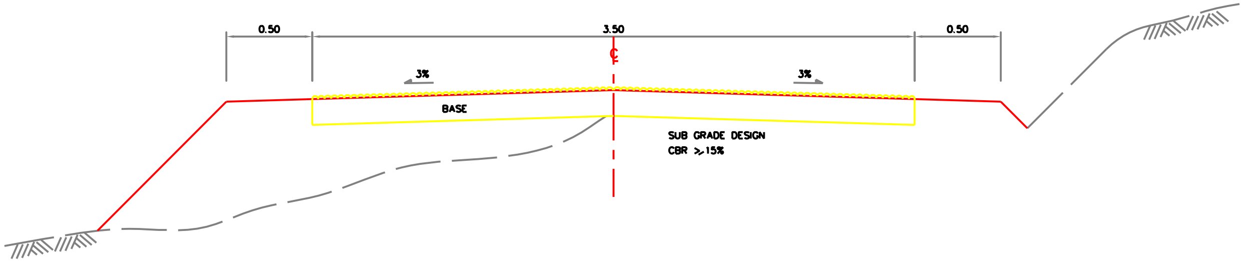
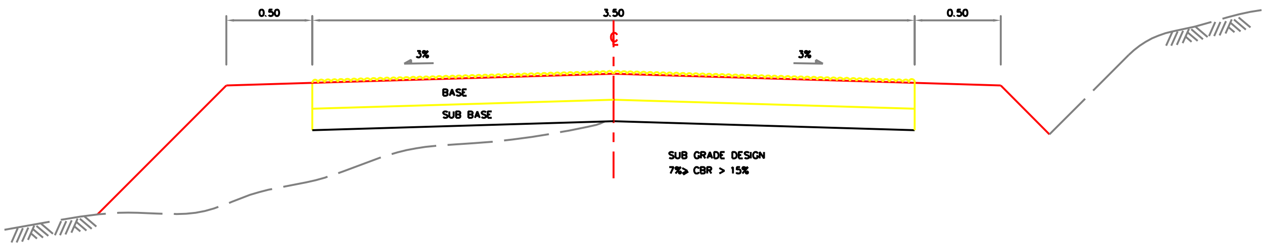
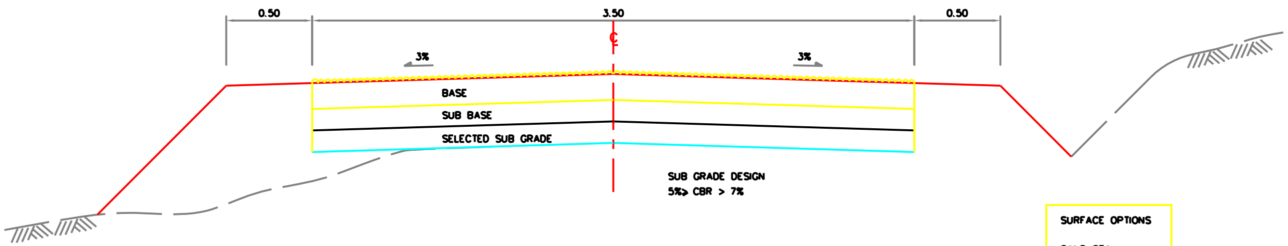
Horizontal:	1:25		







SURFACE OPTIONS

SAND SEAL
OTTA SEAL

	SUB GRADE CBR	BASE	SUB BASE	SELECTED SUB GRADE
LOW VOLUME ROADS	>15%	150mm TYPE3		
	7-15%	150mm TYPE3	120mm TYPE1	
	5-7%	150mm TYPE3	120mm TYPE1	150mm TYPE3
TRH4 GRANULAR BASE	>15%	100mm TYPE3		
	7-15%	100mm TYPE3	125mm TYPE1	
	5-7%	100mm TYPE3	125mm TYPE3	150mm TYPE3
TRH4 STABILISED GRAVEL BASE	>15%	125mm SGB		
	7-15%	125mm SGB	125mm TYPE3	
	5-7%	125mm SGB	125mm TYPE3	150mm TYPE3

REVISIONS			
No.	Description	Approved	Date

LAO PEOPLE'S DEMOCRATIC REPUBLIC

MINISTRY OF COMMUNICATION TRANSPORT POST AND CONSTRUCTION

NORTHERN ECONOMIC CORRIDOR (R3) ADB LOAN No. 1989(SF)

ACCESS ROAD PACKAGE 1

HOUAY XAI DISTRICT

Drawing Title:

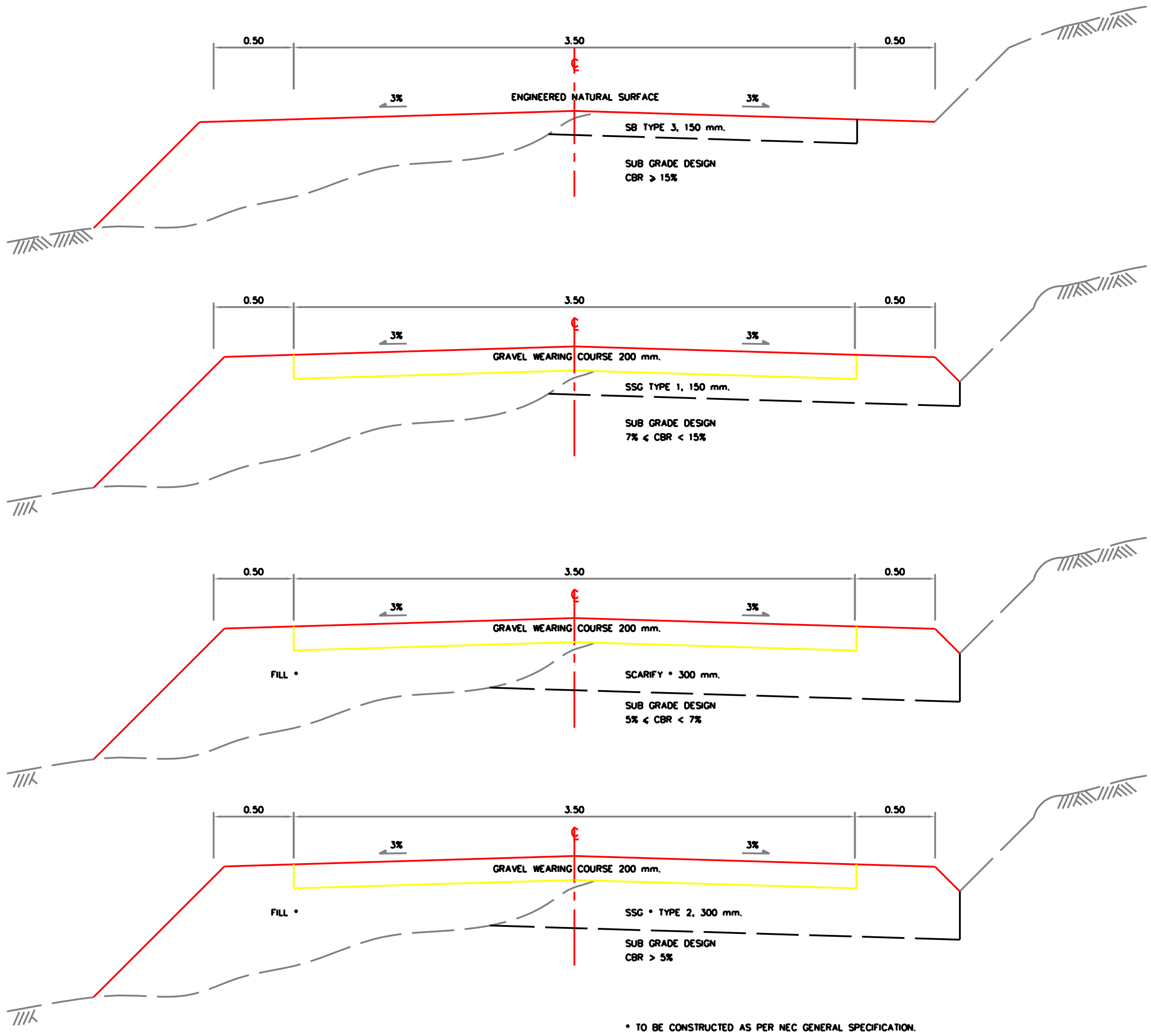
BITUMINOUS SURFACE

Consultant:

Drawn by :
Checked by :
Approved by :

Date:
Date:
Date:

Scale		Drawing No.	Revision
Vertical:	1:25	SP-02	
Horizontal:	1:25		



REVISIONS			
No.	Description	Approved	Date

LAO PEOPLE'S DEMOCRATIC REPUBLIC
MINISTRY OF COMMUNICATION TRANSPORT POST AND CONSTRUCTION
NORTHERN ECONOMIC CORRIDOR (R3) ADB LOAN No. 1989(SF)

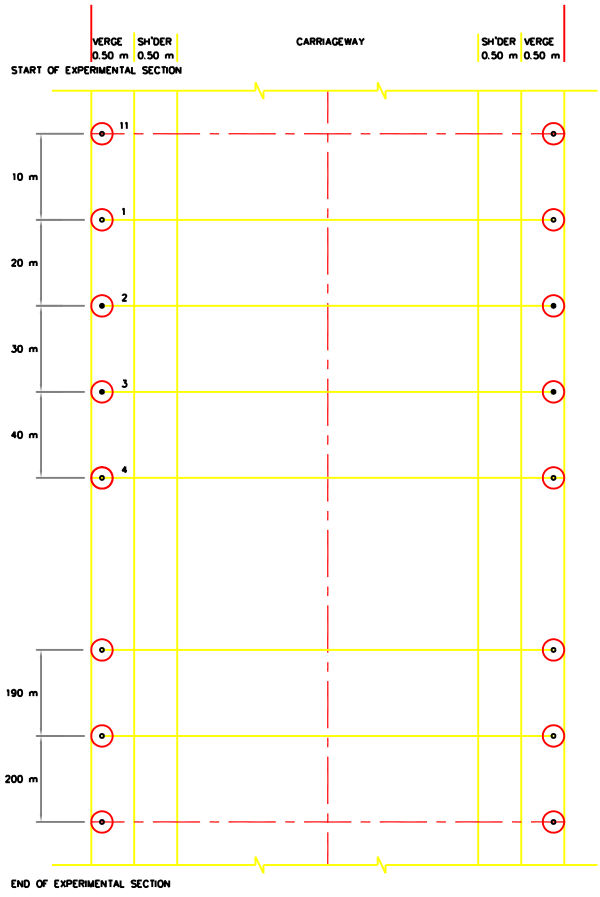
ACCESS ROAD PACKAGE 1
HOUAY XAI DISTRICT

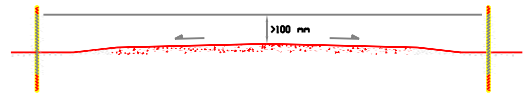
Drawing Title:
GRAVEL PAVEMENT

Consultant:

Drawn by :		Date:	
Checked by :		Date:	
Approved by :		Date:	
Scale		Drawing No.	Revision
Vertical:	1:25	SP-01	
Horizontal:	1:25		

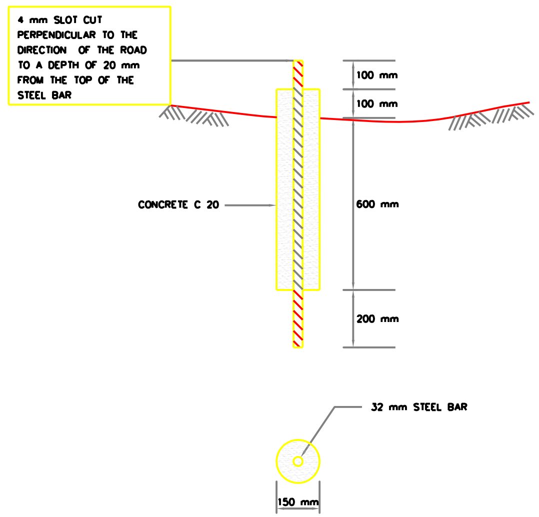
LOCATION





1. THE TOP OF THE EACH STEEL BAR IS TO BE APROXIMATLY 100 mm ABOVE THE CROWN OF THE ROAD.
2. THE TOP OF EACH STEEL BAR IS TO BE ACCURATELY LOCATED (X,Y,Z).
3. THE CROWN OF THE ROAD IS TO BE ACCURATELY LOCATED (X,Y,Z).
4. THIS IS A GRID WILL BE FORMED WITH THE LEVELS NOTED

CONSTRUCTION DETAIL



REVISIONS			
No.	Description	Approved	Date

LAO PEOPLE'S DEMOCRATIC REPUBLIC

MINISTRY OF COMMUNICATION TRANSPORT POST AND CONSTRUCTION

NORTHERN ECONOMIC CORRIDOR (R3) ADB LOAN No. 1980(SF)

ACCESS ROAD PACKAGE 1

HOUAY XAI DISTRICT

Drawing Title:

MONITORING BEACONS

Consultant:

Drawn by :		Date:	
Checked by :		Date:	
Approved by :		Date:	
Scale		Drawing No.	Revision
Vertical:		SP-08	
Horizontal:			

Appendix 6

Trial Pavement Specifications

MASTER LIST OF CONTENTS

Page No

Section 900 – TRIAL PAVEMENTS

SECTION 901

GENERAL
LIST OF CONTENTS

901 GENERAL

901.1 Description

This specification describes the materials, construction methods and method of monitoring of pavement trial sections to be constructed on the selected rural assess roads.

Each trial length shall be preceded by a 100 m training section, however where the pavement structure does not change significantly a number of trial lengths may follow one another and a single training section.

901.2 Testing Prior to Construction

The approximate start and end locations for the trial lengths have been selected as shown in the bid documents, however this is indicative only and further testing is required prior to the construction to finalise the trial locations.

For tender purposes the testing regime as shown below must be priced in the Bills of Quantities in order to accurately assess the subgrade conditions along the proposed route of the access roads. This work does not include the Contractor's normal testing of materials in order to obtain suitable construction materials.

Testing Requirements Prior to Construction (for tender purposes only)

Test	Number	Method
Field testing.		
Dynamic Cone Penetrometer Tests along the proposed Centreline	1 test per 100 m	ORN31 and as instructed by the Engineer
Dynamic Cone Penetrometer Tests within the proposed Trial Lengths	33 tests per 100 m	ORN31 and as instructed by the Engineer
Trial Pits excavation, logging of the profile and removal of two 100 kg material samples along the proposed Centreline	1 test per 1,000 m	ORN31 and as instructed by the Engineer
Trial Pits excavation, logging of the profile and removal of two 100 kg material samples within the proposed Trial Lengths	2 tests per 100 m	ORN31 and as instructed by the Engineer
Laboratory testing of the samples obtained during the trial pit excavation, above.		
Compaction characteristics and bearing capacity determination	20 tests	
Particle Size Distribution	30 tests	
Atterberg Limits including Linear Shrinkage	60 tests	

SECTION 902

EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL
LIST OF CONTENTS

902 EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL

902.1 Treatment of the Subgrade

Treatment of the in-situ subgrade is as follows:

If the subgrade design bearing capacity is CBR<5% then the construction procedure is as described in the General Specification which will result in a 300 mm layer of selected subgrade material with CBR≥8% being applied.

If the subgrade design bearing capacity is 5%≤CBR<7% then the construction procedure is as described in the NEC design specification which will result in the top 300 mm of in-situ material being scarified and compacted as defined in the General Specification.

If the subgrade design bearing capacity is 8%≤CBR<15% then the construction procedure is to scarify and recompact the top 150 mm of the in-situ material as specified under selected subgrade in this specification.

If the subgrade design bearing capacity is CBR≥15% then the construction procedure is to scarify and recompact the top 150 mm of the in-situ material as specified under subbase in this specification.

902.2 Materials

This section describes the materials that are to be used for the construction of the trial sections.

902.2.1 Sands, Natural Gravel and Aggregates

Gravel material shall be obtained from approved sources in borrow areas or cuts.

The requirements to be complied with by the material are set out either on the Drawings or in the Project Specifications for each of the pavement layers and, despite the indications on the Drawings regarding the possible use of the sources of natural material tested, it shall be incumbent on the Contractor to use only material which complies with the prescribed requirements for use in the relevant pavement layers.

902.2.2 Selected Layers

In situ material falling within the selected subgrade horizon shall, when not conforming with the requirements for selected subgrade material, shall be excavated and replaced or stabilised as ordered by the Engineer. Selected subgrade shall contain no material greater than two-thirds of the layer thickness in the case of both unstabilised and stabilised materials. The material will conform to the following requirements when unstabilised:

Minimum soaked CBR at the specified density:

Selected Subgrade	***Type 1***	***Type 2***	**Type 3**
Bearing Capacity at 93% MDD Modified AASHTO	CBR≥15%	CBR≥8%	CBR≥7%

Maximum Plasticity Index (PI) = 3 x grading modulus + 10, where the Grading Modulus (GM) is defined as the cumulative percentages by mass of material in a representative sample of aggregate, gravel or soil retained on the 2.00 mm, 0.425 mm and 0.075 mm sieves, divided by 100.

902.2.3 Subbase

Subbase materials shall be obtained from approved sources in borrow or cut or such other sources as may be specified or approved from time to time.

The completed subbase shall contain no material having a maximum dimension larger than 63 mm or larger than two-thirds of the compacted layer thickness when approved by the Engineer.

Subbase material shall, unless otherwise authorised, conform to the following requirements when finally placed:

(a) Grading Modulus

The minimum grading modulus shall be 1.5 unless authorised by the Engineer, in which case a minimum of 1.2 may be permitted. The grading modulus may be relaxed to below 1.2 at the discretion of the Engineer when no alternative subbase material exists provided that the specified CBR strength is obtained.

Subbase	***Type 1***	***Type 2***	**Type 3**
Grading Modulus	GM≤1.2	GM≤1.5	GM≤1.5

(b) Plasticity Index

The maximum plasticity index of the natural material shall be 10% and that for material to be stabilised shall not exceed 6% after treatment with the selected stabilising agent.

(c) California Bearing Ratio

Minimum soaked CBR at the specified density:

Subbase	***Type 1***	***Type 2***	**Type 3**
Bearing Capacity at 95% MDD Modified AASHTO	CBR≥30%	CBR≥25%	CBR≥15%

902.2.4 Base

Gravel base material shall be obtained only from approved borrow areas or such other sources of supply as may be specified or approved for use from time to time.

The completed base shall contain no material having a maximum dimension exceeding 53 mm.

Gravel base material shall, unless otherwise authorised, conform to the following requirements when finally placed.

Sieve size (mm)	***Percentage passing by mass Natural base***	**Percentage passing by mass Chemically stabilised base**
37.5	80 – 100	80 – 100
19.0	60 – 90	60 – 100
4.75	30 – 65	30 – 80
2.00	20 – 50	20 – 63
0.425	10 – 30	10 – 41
0.075	5 – 15	5 - 20

(a) Grading Modulus

The minimum grading modulus shall be 2.0 if unstabilised or 1.7 if the material is to be chemically stabilised.

(b) Plasticity Index

The maximum plasticity index of the natural material shall be 6% and that for material to be stabilised shall not exceed 6% after treatment with the selected stabilising agent.

(c) California Bearing Ratio

Minimum soaked CBR at the specified density:

Base	***Type 1***	***Type 2***	**Type 3**
Bearing Capacity at 98% MDD Modified AASHTO	CBR≥80%	CBR≥65%	CBR≥55%

902.2.5 Shoulder and Wearing Course

Shoulders will either be constructed from the same material as the base course or imported gravel. Imported gravel for shoulders shall conform to the requirements for wearing course gravels as follows:

Maximum size	37.5 mm
Maximum percentage retained on 37.5 mm sieve	5%
Shrinkage product	100 – 365
Grading coefficient	16 – 34
Minimum soaked CBR at 95% mod AASHTO	15%

Note: Shrinkage product = Bar linear shrinkage x per cent passing 0.425 mm
Grading coefficient = (per cent passing 26.5 mm - per cent passing 2.0 mm) x per cent passing 4.75 mm/100

902.3 Pavement Layers of Natural Gravel

902.3.1 Description

This Section covers the construction of the embankment selected layers, subbase, base and shoulders, and gravel wearing courses from approved natural gravel or partially crushed gravels.

Pavement layers shall be constructed only where the underlying layer meets all the specified requirements and has been approved by the Engineer. Before the construction of any pavement layer, and also before any material for a pavement layer is dumped on the road, the Contractor shall check the underlying layer to establish whether there is any damage, wet spots or other defects, which shall be rectified in accordance with the instructions of the Engineer before the next layer is constructed.

902.3.2 Placing and Compacting

The material for a pavement layer shall be placed, spread, broken down, watered if necessary and mixed, and oversize material shall be removed and the layer compacted, all in accordance with the requirements of these Specifications.

The minimum in situ compaction of gravel material shall be as specified hereinafter for the respective layers in terms of a percentage of modified AASHTO density.

Selected Subgrade	93%
Subbase	95%
Base	98%
Shoulder and Wearing Course	95%

902.3.3 Gravel Base

Coarse gravel containing non-plastic or slightly plastic soil fines and used in the construction of the gravel base will usually require slushing and rolling in addition to the compaction specified in these Specifications in order to obtain a firm, well-knit surface. If so directed by the Engineer, the base, after being processed and compacted as specified above, shall be well watered by the Contractor over short lengths at a time, slushed and rolled with compactors and/ or heavy flat-wheel rollers of a mass of not less than 10 tonnes each. Watering and rolling shall continue over a section until all excess fines have been brought to the surface of the layer. Such excess fines shall be uniformly spread over the entire surface of the layer by means of stiff brooms, and watering, rolling and brooming shall continue until all areas deficient in fines have been suitably corrected. All excess fines shall finally be removed from the surface of the layer.

(a) Shoulders

Work shall be undertaken on the shoulders so constructed that the road will be adequately drained at all times by means of temporary drainage pipes passing through the shoulders.

(b) Crushing and Screening

Where pavement material cannot be suitably broken down to the required size in excavation and during processing on the road, the Engineer may prescribe that the material be crushed and screened or crushed only, all as specified in these Specifications.

(c) Stabilisation

When specified or required by the Engineer, pavement layers shall be stabilised as specified in Section 902.5.

902.3.4 Protection and Maintenance

The Contractor shall protect and maintain the completed pavement layers. Protection includes protection against rain and flood water and against any undue wear and tear of or damage to unsealed layers by construction or other traffic. Maintenance shall include, inter alia, the immediate repair of any damage or defects that may occur, excluding the normal wear and tear of bases and wearing courses, and shall be repeated until the end of the maintenance period.

902.4 Cement Stabilisation

902.4.1 Description

This Section covers the stabilisation of materials used in the construction of the roadbed, fill or pavement layers by the addition of a chemical stabilising agent or by the mechanical modification of the material by mixing various materials or by treating the material with a bituminous stabilising agent.

It includes the furnishing, spreading and mixing-in of the stabilising agent or soil binder. In the case of chemically stabilised material the layer is given a curing treatment.

902.4.2 Materials

The stabilising agent shall be either one or more of the following agents specified on the Drawings, in the Schedule of Quantities or in the Project Specifications or ordered by the Engineer:

(i) Road Lime. Road lime shall comply with the requirements of the national specification for lime or AASHTO M 216 where no local standard exists.

(ii) Ordinary Portland Cement. Ordinary Portland cement shall comply with the requirements of the national specification or AASHTO M 85 where no local standard exists. The use of rapid-hardening Portland cement shall not be permitted.

From the time of purchase to the time of use, all stabilising agents shall be kept under proper cover and be protected from moisture.

Consignments of these materials shall be used in the same sequence as that in which they are delivered at the Works.

Stocks which have been stored on the site for periods longer than three months shall not be used in the work, unless authorised by the Engineer.

The properties of the material after stabilisation will be specified in the Drawings and design. In order to ensure that a durable stabilisation reaction occurs, the amount of stabiliser added should not be less than the initial consumption of lime (ICL) plus 1%. A stabiliser content in excess of 5% is not normally specified in order to avoid excessive shrinkage cracking.

902.4.3 Construction Requirements

(a) Preparing the Layer

The material to be stabilised shall be prepared and placed as specified in Section 902, and given at least one pass with a flatwheel roller. The material shall be damp.

(b) Applying the Stabilising Agent

After the layer of soil or gravel has been prepared, the stabilising agent shall be spread uniformly over the full area of the layer at the prescribed rate of application by means of an approved type of mechanical spreader in a continuous process, or it may be spread by hand.

When spreading is done by hand, pockets or bags of stabilising agent shall be accurately spaced at equal intervals along the section to be stabilised so that the specified rate of application can be achieved. The stabilising agent shall be spread as evenly as possible, and shall then be uniformly distributed over the entire surface to be treated by levelling off the stabilising agent by means of hand rakes and/or screeds.

The Engineer may permit spreading of the hand-spaced stabilising agent by motor grader, provided that he is satisfied that an even distribution of the stabilising agent is obtained.

(c) Mixing in the Stabilising Agent

Immediately after the stabilising agent has been spread, it shall be mixed with the loose gravel for the full depth of treatment. Care shall be taken not to disturb the compacted layer underneath, nor to mix the stabilising agent in below the desired depth. Mixing shall be continued for as long as necessary and repeated as often as required to ensure a thorough, uniform and intimate mix of the soil or gravel and the stabilising agent over the full area and depth of the material to be treated and until the resulting mixture is homogeneous and of uniform appearance throughout.

Mixing shall be done by grader, disc harrow, rotary mixer or equivalent plant, working over the full area and depth of the layer to be stabilised by means of successive passes of the equipment.

Mixing may also be done in central batch-mixing plants, but the Contractor will not be entitled to payment for additional overhaul or incidentals resulting from such procedure, unless such mode of operation has been prescribed.

(d) Watering

Immediately after the stabilising agent has been properly mixed with the soil or gravel, the moisture content of the mixture shall be determined, and the required amount of water shall be added for optimum moisture content.

Each application or addition of water shall be well mixed with the gravel or soil so as to avoid the concentration of water near the surface or the flow of water over the surface of the layer.

Particular care shall be taken to ensure satisfactory moisture distribution over the full depth, width and length of the section being stabilised and to prevent any portion of the work from getting excessively wet after the stabilising agent has been added. Any portion of the work that becomes too wet after the stabilising agent has been added and before the mixture has been compacted, will be rejected, and such portions shall be allowed to dry out to the required moisture content and shall then be scarified, restabilised, recompacted and again finished off in accordance with the requirements specified herein, all at the expense of the Contractor. The water supply and watering equipment shall be adequate to ensure that all the water required will be added and mixed with the material being treated within a short enough period to enable compaction and finishing to be completed within the period specified in Subclause 902.5.3(h).

(e) Compaction

The provisions of Section 902 shall apply. During compaction the layer shall be continuously bladed by motor grader, and loss of moisture by evaporation shall be corrected by further light applications of water.

During compaction of the stabilised layers, the Contractor shall lightly harrow or scarify the crust before final rolling, if so required by the Engineer, in order to prevent the formation of laminations near the surface of the layer. Final rolling shall be done with equipment that will give a smooth surface finish which conforms to the surface tolerances specified. Low patches on the surface may not be filled after compaction. The minimum compaction requirements shall be as specified for the particular layer in the various Sections of these Specifications.

A sufficient number of compacting units shall be employed on the work to ensure that, from the time the stabilising agent is first applied to the layer, the mixing process, watering, compacting, shaping and final finishing will be completed within the periods specified in Subclause 902.5.3(h) below.

(f) Finishing at Junctions

Any finished portion of the stabilised layer adjacent to new work, which is used as a turn-round area by equipment in constructing the adjoining section, shall be provided with a protective cover of soil or gravel of at least 100 mm thick over a sufficient length to prevent damage to work already completed. When the adjoining section is being finally finished, such cover shall be removed to permit the making of a smooth vertical joint at the junction of the different sections. Material in the vicinity of the joint which cannot be processed satisfactorily with normal construction equipment shall be mixed and compacted by hand or with suitable hand-operated machines.

(g) Curing the Stabilised Work

The stabilised layer shall be protected against rapid drying out for at least seven days following completion of the layer.

The methods of protection may be any one or more of the following:

(i) The stabilised layer shall be kept continuously wet or damp by watering at frequent intervals. This method will be permitted for up to a maximum period of 24 hours, but one of Methods (ii), (iii), or (iv) shall be applied as soon as the moisture content of the stabilised layer so permits. Work which is not kept continuously wet or damp but is subjected to consecutive wet-dry cycles, may be rejected by the Engineer should he consider the layer to have been adversely affected.

(ii) The stabilised layer shall be covered with the material required for the following layer while the stabilised layer is still in a wet or damp condition. The material forming the protective layer shall be watered at such intervals as may be required to keep the stabilised layer continuously wet or damp, and in dry weather this shall be done at least once in every 24 hours.

(iii) The stabilised layer shall be covered with a curing membrane consisting of a spray-grade emulsion or cutback bitumen applied at the rate instructed by the Engineer.

(iii) Where a prime coat is specified on top of the stabilised base or Subbase, the prime coat may be utilised as a curing membrane.

No additional payment will be made for curing as described above.

(h) Construction Limitations

For cemented layers, the stabilising agent shall be applied only to an area of such size that all processing, watering, compacting and finishing can be completed within an 8 hour period.

For modification, the maximum period allowed from the time the binder comes into contact with the layer being modified until the completion of compaction shall be 48 hours in the case of lime. The starting time shall be the median time taken to complete the spreading of the lime. Modification of materials should only be carried out to improve the properties of the material prior to chemical stabilisation. Modification alone will usually be lost rapidly through carbonation.

No stabilisation shall be applied when the moisture content of the material to be stabilised exceeds the optimum moisture content by more than 2% of the dry mass of material. No stabilisation shall be done during wet weather or when, in the opinion of the Engineer, windy conditions may adversely affect the stabilising operations. Any rain falling on the working area during the process of stabilisation may be sufficient cause for the Engineer to order any affected areas to be reconstructed at the Contractor's own cost.

No traffic nor any equipment not actually used for processing the layer may be allowed to pass over the freshly spread stabilising agent. Only equipment required for curing or priming may be allowed over the treated layers during the specified curing period. Where water spraying equipment causes damage to the layer, the Engineer may direct that watering shall be done by side-spraying tankers travelling off the stabilised layer.

902.4.4 Quality of Materials and Workmanship

(a) Stabilising Agent

The Contractor shall keep detailed records of the quantities of stabilising agent applied to the road and the volume of material stabilised, and shall make these records available to the Engineer. He shall also monitor the rate of application when using bulk spreading equipment, by taking a canvas patch or tray test every 200 m, unless the Engineer has permitted that the number of tests may be reduced. When using a bulk spreader on Site for the first time or after it has been adjusted or repaired, the spread rate shall be checked by at least five tests over as short a distance as is practicable, with the equipment running at normal speed without stops. Spreading shall not continue on a large scale until the spread rate is within permissible tolerances.

(b) Compaction

The requirements for process control in respect of compaction shall be the same as those stated for the unstabilised layers in each section. Modified AASHTO densities shall be determined.

(c) Routine Inspection and Testing

Routine inspection and testing will be made by the Engineer to determine the quality of materials and workmanship for compliance with the requirements of this Section.

The binder content as determined by the sample mean of a lot shall be not more than 0.5% above the value specified or ordered by the Engineer. Compliance with the requirements for the compaction of stabilised materials shall be as specified in the relevant section for each layer, or in the Project Specifications.

When the tests for uniformity of mix are not applicable, the material shall be visually appraised for uniformity of mix.

(d) Defective Work or Materials

Any material or work which does not comply with the requirements specified shall be removed and replaced with new materials or work complying with the specified requirements or, if the Engineer permits, be repaired , so that it will comply with the specified requirements after having been repaired.

902.5 Measurement and Payment

902.5.1 Unstabilised Material

Measurement will be as follows:

Item No.	Description	Unit
902.1	Selected Subgrade: Type 1 Type 2 Type 3	Cubic Metre (m^3)
902.2	Subbase: Type 1 Type 2 Type 3	Cubic Metre (m^3)
902.3	Base: Type 1 Type 2 Type 3	Cubic Metre (m^3)
902.4	Shoulder and Wearing Course	Cubic Metre (m^3)

Materials shall be measured as compacted to the required density on the approved subgrade, according to the theoretical dimensions shown on the Drawings or as otherwise specified by the Engineer.

No measurement for over-depth shall be made even when such over-depth of material is permitted to remain in place by the Engineer. Unauthorised over-depth shall be at the Contractor's own expense.

902.5.2 Stabilising Agent

Measurement will be as follows:

Item No.	Description	Unit
902.5	Chemical stabilisation extra over unstabilised compacted layers	Cubic Metre (m^3)

The unit of measurement shall be the cubic metre of stabilised material, the quantity of which shall be determined in accordance with the authorised dimensions of the layers treated as instructed by the Engineer.

The tendered rates for chemical stabilisation shall be paid as extra over the rates tendered for constructing the unstabilised layers. The tendered rates for chemical stabilisation shall therefore include full compensation for spreading and mixing the stabilising agent, curing the stabilised sections, any extra water required, and all materials, supervision, labour, plant, equipment, tools and incidentals (extra over those provided for in the rates tendered for constructing the unstabilised layer) necessary for completing the specified work, but excluding the cost of supplying the stabilising agent. No distinction shall be made in respect of the type of stabilising agent used, the time for completion or the specific layer being stabilised, and the extra over rate tendered shall apply to any combination of these. The Engineer reserves the right to vary the thickness of the layer to be stabilised by up to 20 mm, and the contract rate for this work shall not be amended by such change. The Contractor will, however, not be called upon to stabilise any layer less than 100 mm nor more than 200 mm in thickness.

Measurement will be as follows:

Item No.	Description	Unit
902.6	Chemical stabilising agent: (a) Ordinary Portland cement (b) Portland blast-furnace cement (c) Slaked road lime (type indicated)	Tonne (t)

The unit of measurement shall be the tonne of stabilising agent.

The quantity will be determined in accordance with the authorised rate of application or actually provided within the layer concerned, whichever is the lesser quantity, provided, however, that any tests for stabiliser content which indicate an average stabiliser content below that specified, but within the tolerance allowed, shall not be construed as an indication of insufficient stabiliser quantity.

The right of the Engineer to accept work not containing the full quantity of stabiliser specified or ordered, subject to payment of only the actual amount of stabiliser provided, shall not mean that he waives the right to condemn such work.

The tendered rates shall include full compensation for providing the stabilising agent at the Works, irrespective of the rate of application specified or ordered by the Engineer, but shall make allowance for the differences in mixing and compaction times specified for various stabilising agents.

SECTION 903

BITUMINOUS SURFACES
LIST OF CONTENTS

903 BITUMINOUS SURFACES

903.1 Prime Coat

903.1.1 Description

This work shall consist of the careful cleaning of the surface to be primed and applying a low viscosity bituminous binder on the approved base and on any other surfaces ordered by the Engineer in accordance with this Specification, and in conformity with the lines shown on the Drawings.

903.1.2 Materials

Prime coat shall consist of a medium curing cut back bitumen whose viscosity has been reduced by the addition of a volatile diluent. It shall be free from water, show no separation prior to use, and shall conform to all the requirements for Grade MC-70 medium curing cutback bitumen specified in AASHTO M82, when applied to crushed stone base course. Alternative types and grades of cut back bitumen, or bitumen emulsion may be utilized on the Engineers approval, where the contractor can demonstrate its satisfactory performance.

903.1.3 Construction Requirements

(a) Preparation of Surface

Prior to the application of prime coat, all loose materials shall be removed from the surface and the surface shall be cleaned by means of approved mechanical sweepers or blowers and/or hand brooms, until it is as free from dust as is deemed practicable.

Prime coat shall be applied only when the surface to be treated is dry, or contains moisture not in excess of that which will permit uniform distribution and the desired penetration.

If deemed necessary by the Engineer, the cleaned surface shall be given a light application of water and allowed to dry to a surface dry condition before the bituminous material is applied.

No traffic shall be permitted on the surface after it has been prepared to receive the prime coat.

Prime coat shall be applied only when the ambient temperature is above 15°C and rising and when the weather is dry and no rain is expected.

(b) Heating Equipment

Heating equipment for heating bituminous materials shall be of adequate capacity to heat the material properly by circulating steam or hot oil through coils of a tank or by circulating the material around a system of heated coils or pipes, or by circulating the material through a system of coils or pipes enclosed in a heated jacket or other approved means.

Heating equipment shall be operated in a manner that will not damage the material.

Heating equipment shall be so constructed that it will prevent the direct flame from a burner from striking the surface of the coils, pipes, or jacket through which the material is circulated.

If storage tanks are used, thermometers with a range of 0 to 200°C shall be fixed to the tanks so that the temperature of the material may be determined at all times.

Material which has been heated above 125°C will be rejected.

All storage tanks, piping, retorts, booster tanks and distributors used in storing, handling or heating material shall be kept clean and in good condition at all times, and shall be operated in such manner that there will be no contamination by foreign material.

(c) Pressure Distributors

Pressure distributors shall be self-propelled, pneumatic-tyred and so designated and equipped as to distribute the prime coat uniformly in variable widths at readily determined and controlled rates. They shall be operated by skilled workmen. The equipment shall include instruments for measuring the speed of travel accurately at low speeds, the rate of flow of bituminous material through the nozzles, the temperature of the contents of the tank, and the pressure and remaining contents. If after beginning the work, the distribution of bituminous material is found to be in error, the equipment shall be withdrawn from the work and calibrated to the satisfaction of the Engineer before proceeding with the work.

The nozzles and spray bar shall be adjusted and frequently checked so that uniform distribution is achieved. Spraying shall cease immediately upon any clogging or interference of any nozzle, and corrective measures shall be taken before spraying is resumed.

(d) Application

Prime coat shall be applied at the rates directed by the Engineer after the field trials. Any application so determined may be divided into two applications where necessary to prevent prime coat flowing off the surface and additional material shall be applied where localized surface conditions indicate it to be necessary.

Prime coat shall not be applied when the temperature is below 15°C, unless otherwise permitted by the Engineer. The temperature of prime coat at the time of spraying shall be in the range 57 to 71°C.

Any skipped areas or recognized deficiencies shall be corrected by means of approved hand sprays. The use of hand sprays will only be allowed for correcting such deficiencies and for priming small patches or areas which are inaccessible to the distributor.

The Contractor shall spread blotting material on all areas which show an excess of prime. Blotting material shall be applied sparingly and only on areas which have not dried. Blotting material shall comprise clean non plastic sand, or fine aggregate.

(e) Field Trials

The Contractor shall, before he commences the work proper, carry out field trials to permit the Engineer to ascertain the rate of application to be ordered. The trial methods shall be approved by the Engineer and performed by the Contractor in the presence of the Engineer.

The rate of application in the field trials shall be 0.6 l/m^2 minimum and 1.2 l/m^2 maximum.

The Engineer may order subsequent field trials and/ or change the previously established rates of application when he deems it necessary.

(f) Protection of Adjacent Structures

When prime coat is being applied, the surfaces of all structures, guard rails, kerbs and other roadway appurtenances shall be protected in a manner approved by the Engineer to prevent them from being splattered or damaged.

The Contractor shall at his own cost make good to the satisfaction of the Engineer any appurtenances which are splattered or damaged.

(g) Traffic Control and Maintenance of Primed Surfaces

The Contractor shall provide all necessary detours for the public and his constructional traffic. Where no convenient detour can be constructed, the application operation shall be confined to one-half of the roadway at a time, and the Contractor shall provide traffic control as directed by the Engineer, at his own cost. The lane of prime coat shall be allowed to penetrate not less then 4 hours, then covered with blotting material if required, and opened to traffic before prime coat is applied to the adjacent lane.

The Contractor shall protect all primed surfaces and keep them in perfect condition until they are covered by succeeding courses.

All areas where the prime surface has been damaged by traffic or by the Contractor's operations shall be cleaned of all loose materials, re-primed, and made good to the satisfaction of the Engineer, at the Contractor's own cost.

903.2 Surface Dressing

903.2.1 Description

This work shall consist of the application of bituminous seal coat followed by aggregate cover material to primed surfaces, all in accordance with the Specification and in conformity with the lines shown on the Drawings or ordered by the Engineer.

903.2.2 Materials

(a) Bitumen Seal Coat

Seal coat shall consist of cut back bitumen binder. It shall be free from water, show no separation prior to use, and shall conform to all the requirements for Grade MC3000 medium-curing cutback bitumen as specified in AASHTO M81. 150/200 penetration grade bitumen or MC 3000 cutback grade bitumen shall be used in warm weather. In cold weather, when night temperatures are likely to fall below 10oC, MC 800 cutback grade bitumen may be used or alternatively 150/200 penetration grade bitumen may be cutback with power paraffin to the appropriate viscosity range as directed by the Engineer

Alternate types and grades of cut back bitumen, or bitumen emulsion may be utilized on the Engineers approval, where the contractor can demonstrate its satisfactory performance.

(b) Sand

The following conditions must be met:

(i) Grading

The grading shall conform to the following table:

Sieve size (mm)	***Percentage by mass passing through sieve***
6.7	*100*
0.300	*0 - 15*
0.150	*0 - 2*

The sand shall be screened to ensure the removal of all material exceeding 6.7 mm. Water shall be used to assist the screening process and to clean the sand of dust and foreign matter.

(ii) Sand equivalent

The sand equivalent shall be at least 35.

(c) Aggregate for Otta Seals

Crushed rock or screened river gravel shall be used. The grading curve for the Otta Seal shall fall smoothly within the envelopes detailed in the following table.

Grading	**Open grading**	**Medium grading**	***Dense grading***
19	100	100	*100*
16	80 – 100	84 – 100	*93 – 100*
13.2	52 – 82	68 – 94	*84 – 100*
9.5	36 – 58	44 – 73	*70 – 98*
6.7	20 – 40	29 – 54	*54 – 80*
4.75	10 – 30	19 – 42	*44 – 70*
2.00	0 – 8	3 – 18	*20 – 48*
1.18	0 – 5	1 – 14	*15 – 38*
0.42 5	0 – 2	0 – 6	*7 – 25*
0.075	*0 – 1*	*0 – 2*	*3 – 10*

The upper nominal size shall not be larger than 16,0mm, if not otherwise directed by the Engineer. The aggregate strength requirements shall be according to the following table.

Aggregate Strength Requirements	
LA Abrasion	35% max
Min. Wet/Dry strength ratio	0. 6 0

If crushed material is used the weighted Flakiness Index should be determined on the following fractions 9.5 - 13.2 mm, 6.7 - 9.5 mm and 4.75 - 6.7 mm sieves, and should not exceed 30.

(d) Sand for Otta Cover Seal

The materials used can be crusher dust or river sand and shall be non-plastic, free from organic matter and lumps of clay. All the material shall pass the 6.7 mm sieve, unless otherwise approved by the Engineer.

903.3 Construction Requirements

903.3.1 Application of Seal Coat

Seal coat shall be applied by means of a pressure distributor in a uniform, continuous spread over the section to be treated and within the temperature range specified. The quantity of material per square metre shall be within the limits hereinafter specified and as directed by the Engineer.

A strip of building paper, at least 1 m wide and with a length equal to that of the spray bar of the distributor plus 300 mm, shall be used at the beginning of each spread. If the cut-off is not positive, the use of paper may be required by the Engineer at the end of each spread. The paper shall be removed and disposed of in an approved manner. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected in an approved manner. Junctions of spreads shall be carefully made to assure a smooth riding surface.

Heating and spraying temperatures shall be in accordance with the following table.

Materials	Heating and spraying temperatures (°C)		
	Min	Max	Recommend
Road grade bitumens 150/200 pen grade 80/100 pen grade	150 165	175 190	165 175
Cut-back bitumens RC-250 MC-800 MC-3000	90 110 135	115 135 155	100 125 145
Bituminous emulsions 60% 65% 70%	Air Air Air	60 60 60	60 60 60

The length of spread of seal coat shall not be in excess of that which trucks loaded with cover coat material can immediately cover (maximum elapsed time of 2 minutes).

The width of spread of seal coat shall not be more than 150 mm wider than the width covered by the cover coat material from the spreading device. Under no circumstances shall operations proceed in such manner that seal coat is allowed to cool or otherwise impair retention of the cover coat.

The distributors shall be so designed that, when not spreading, it does not drip.

Distribution of the seal coat shall be so regulated and sufficient material shall be left in the distributor at the end of each application so that there is a uniform distribution of material. In no case shall the distributor be allowed to expel air, thereby causing uneven coverage.

The angle of the spray nozzles and the height of the spray bar shall be so adjusted and frequently checked that uniform distribution is obtained. If the raise of the spray bar as the load is removed is excessive and contributes to drilling and streaking of the seal coat, the frame of the distributor shall be blocked or snubbed to the axle of the truck to maintain a constant height of the spray bar above the road surface. The distribution shall cease immediately upon any clogging or interference of any nozzle and corrective measures shall be taken before distribution is resumed.

The seal coat distribution operation shall not be more than 300 m ahead of the spreading of the aggregate (or such length as can be covered by aggregate within 1 minute).

The seal coat shall be applied at 0.8 l/m^2 net bitumen and immediately after the coat has been spread, the aggregate shall be distributed thereon at a rate of 0.007 m^3/m^2 and rolled . Where emulsions are used, the aggregate shall be applied only after the emulsions have broken partially.

During the rolling process, any uneven application of sand shall be rectified with a light broom drag or other suitable apparatus.

Where the binder is required to be applied in two applications, the surface can be opened to controlled traffic after the first application of binder and sand, as soon as it is convenient to do so. The second application of binder and sand may be applied when the first application has cured sufficiently for it to take the traffic without requiring brooming back of the sand. All loose sand and deleterious material shall be removed from the surface and any damaged or defective areas rectified before the second application of binder and sand. While the traffic is using the road, the sand shall be continuously broomed back onto the road until the binder has cured sufficiently to retain the sand and until traffic does not damage the surface. The sweeping-back process shall be done with a rotary broom and may take as long as two months before the surface finally retains all of the sand. As wet sand is difficult to apply, the preparation of the sand should be done well ahead of the actual construction to allow the sand to be fairly dry when it is applied. If the sand is not cleaned to the Engineer's satisfaction by one screening and washing operation, it shall be washed again at no extra payment.

903.3.2 <u>Application of Otta Seal</u>

Granular bases do not normally require a prime, unless otherwise directed by the Engineer.

The sealed surface shall receive not less than 20 passes of a 10 – 12 t heavy tandem steel roller. During the following 2 days, the entire sealed area, including the shoulders, shall receive a further minimum of 15 passes daily, unless otherwise approved by the Engineer.

The Engineer may direct even trafficking of the surfaced area and channelling of the traffic may be required for certain periods and traffic cones or similar may be required.

The road should be opened to traffic immediately after the sealing operations are completed, but a maximum speed limit of 50km/h should be enforced during the initial 2 - 3 weeks after construction.

Aggregate that has been dislodged by traffic during the immediate post construction period shall be broomed back into the exposed areas during the first 2 – 3 weeks, as directed by the Engineer.

After 2 - 3 weeks of trafficking the excess aggregate shall be swept off the road surface and the speed limitations can be lifted, unless otherwise directed by the Engineer. If natural gravel is used with a fairly high content of fines, the period may be extended to 6 weeks or as directed by the Engineer.

A team shall be retained on site to deal with areas of bleeding if required. The team will be required during the normal construction period as well as during the first hot season following the completion of sealing operations.

A minimum period of 8 - 12 weeks should normally elapse between construction of the subsequent layers of the surfacing, and during that period the road should receive as much heavy trafficking as possible, unless otherwise directed by the Engineer.

Prior to applying the sand cover seal, the surfaced area shall be broomed free of dust and loose stones or other foreign matter

The sand cover seal shall receive on the day of surfacing not less than 15 passes of a roller with a minimum weight of 12 t.

Sand that has been dislodged by traffic during the immediate post construction period shall be broomed back into the exposed areas during the first 2 - 3 weeks as directed by the Engineer.

(i) Binder

All spray rates refer to hot spray rates of binder and shall fall within the ranges given in the following table:

Binder Spray Rates					
		Aggregate Grading			
		Open	**Medium**	**Dense**	
Type of Otta Seal				**AADT <100**	**AADT >100**
Double	1st layer	1.6	1.7	1.8	1.7
	2nd layer	1.5	1.6	2.0	1.9
	Fine sand	0.7	0.7		0.6
Single, with a sand cover seal	Crusher dust or coarse river sand	0.9	0.8		0.7
	1st layer	1.6	1.7	2.0	1.9
Single		1.7	1.8	2.0	1.9

Penetration bitumen 150/200, MC3000 or softer may be used. Power paraffin may be used as a cutter to obtain the required viscosity range as directed by the Engineer. Penetration bitumen 80/100 or stiffer shall not be allowed used unless cut back by the use of both a softener and power paraffin.

The binder for the Otta Seal shall be according to the following table:

ADT at the time of construction	**Type of bitumen**		
	Open grading	**Medium grading**	**Dense grading**
More than 1000	Not applicable	150/200 pen. grade	MC 3000 MC 800 in cold weather
100 - 1000	150/200 pen. grade	150/200 pen. grade in cold weather	MC 3000 MC 800 in cold weather
Less than 100	150/200 pen. grade	MC3000	MC800

No hot spray rates lower than 1.5 l/m² shall be allowed. For tender purposes a rate of 1.7 l/m² shall be used. Absorbent aggregates with a water absorption of more than 2% shall require an additional 0.3 to 0.5 l/m² (in total) for both layers, as directed by the Engineer.

The binder for the sand or crusher dust seal shall be according to the above table of binder spray rates. Penetration bitumen 150/200 shall not be used unless cut back by power paraffin to MC 3000 or MC 800 viscosity ranges.

Suitable hot spray rates shall range from 0.6 to 0.9 l/m² depending on the texture of the underlying seal and the type of sand/crusher dust used in the seal. For tender purposes a rate of 0.8 l/m² shall be used.

(ii) Anti-Stripping Agent

When required, the anti-stripping agent shall be mixed with the hot bitumen by 0.8% by weight of cold bitumen, or as directed by the Engineer.

(iii) Aggregate

The aggregate application rates for Otta Seal aggregate and crusher dust/sand for cover seal shall be in accordance with the following table

AGGREGATE APPLICATION RATES			
	Open grading	**Medium grading**	**Dense grading**
Otta Seals	0,013 –0,016	0,013 –0,016	0,016 –0,020
Sand cover seals	0,010 –0,012		

For tender purposes a rate of 0.015 m³/m² shall be used for Otta Seal aggregate “Open - Medium” grading, and 0.018 m³/m² for “Dense” grading. For sand cover seal a rate of 0.011 m³/m² shall be used.

(b) <u>Maintenance of the Completed Work</u>

When directed by the Engineer, the Contractor shall make good defective areas by further applications of seal coat and/or cover material, and further manipulation as described above, at his own cost.

After all other work has been completed, the excess loose cover material along the edges of the surface shall be broomed and bladed off the shoulder to provide a definite and distinct line along the edge of the sealed surface.

(c) Weather and Temperature Limitations

Surface dressing operations shall be carried on only when the surface is dry, when the atmospheric temperature is above + 15°C, and when the weather is not foggy or rainy. The above requirements may be waived, but only when so directed by the Engineer.

(d) Protection of Adjacent Structures

When bituminous materials are being applied, the surface of all structures, guard rails, kerbs and gutters, and other roadway appurtenances shall be protected in an approved manner to prevent them from being splattered with bituminous material or marred by equipment operation. In the event that any appurtenances become splattered or marred, the Contractor shall at his own expense, remove all traces of bituminous materials, and repair all damage, and leave the appurtenances in an approved condition.

(e) Working Periods

Surface dressing operations shall be so conducted that all manipulation work specified can be completed before sunset and under favourable weather conditions as determined by the Engineer.

(f) Traffic Control

Traffic shall be prevented from running on the courses until the manipulation work has been completed, unless otherwise ordered or permitted by the Engineer.

Once the manipulation work has been completed or the Engineer so orders, traffic shall be directed over the courses. The Contractor shall post signs restricting the speed of traffic to 20 km/h for such periods as the Engineer directs.

903.4 Measurement and Payment

(a) Prime Coat

Prime coat shall be measured by the litre, computed by multiplying the areas to be treated as shown on the Drawings and any other areas ordered by the Engineer, by the appropriate rate or rates of application specified by the Engineer, corrected to 15°C.

Item No.	Description	Unit
903.1	Prime Coat	Litre (l)

No separate payment will be made for the application of blotting material.

(b) Sand Seal

Item No.	**Description**	**Unit**
903.2	Application of tack coat: (i) MC-70 cut-back bitumen,	Litre (l)

	(ii) MC-3000 cut-back bitumen, (iii) Spray-grade emulsion (65% net bitumen), (iv) Spray-grade cationic emulsion (70% net bitumen), (v) 150/200 penetration grade bitumen.	
903.3	Sand	Cubic metre (m^3)

The unit of measurement of tack coat shall be the litre, measured at spraying temperature.

The tendered rates shall include full compensation for procuring and furnishing the material and applying the binder, including all preparatory work to the surface prior to application of the binder.

The tendered rate shall include full compensation for supplying the sand, washing, screening and preparing the sand, applying the sand as specified, as well as brooming the sand back onto the surface as often as is required.

(c) Otta Seal

Item No.	Description	Unit
903.4	Single Otta Seal using: (i) 150/200 penetration grade bitumen (ii) MC 3000 cutback bitumen viscosity grade (iii) MC 800 cutback bitumen viscosity grade	Square metre (m^2)
903.5	Variations in bituminous binder in: (i) 150/200 penetration grade bitumen (ii) MC 3000 cutback bitumen viscosity grade (iii) MC 800 cutback bitumen viscosity grade (iv) Power paraffin	Litre (l)
903.6	Variations in anti-stripping agent	Kilograms (kg)
903.7	Variations in aggregate: (i) Otta Seal: crushed material (ii) crusher dust (iii) sand	Cubic Metre (m^3)
903.8	Sweeping back dislodged aggregate into the wheel tracks, as directed by the Engineer	Kilometre (km)
903.9	Attending to areas of fattiness and bleeding by applying fine aggregates or sand	Kilometre (km)
903.10	Sweeping back dislodged sand into the wheel tracks, as directed by the Engineer	Kilometre (km)
903.11	Supply and mixing of power paraffin for cutting back bitumen	Litre (l)
903.12	Supply and mixing of anti-stripping agent	Kilograms (kg)

The tendered rate shall include full compensation for furnishing all materials, for an unlimited free haul distance whether the materials are obtained from a commercial source or an approved borrow-pit or quarry, marking the centreline, spraying of binders, spreading of aggregates, rolling, removing deleterious material, supplying of water and spraying of haul roads and construction roads, trimming the edges of the completed surface and all other incidentals necessary for completing the work as specified.

SECTION 904

BAMBOO REINFORCED CONCRETE SURFACING
LIST OF CONTENTS

904 BAMBOO REINFORCED CONCRETE SURFACING

904.1 Description

The works in this section consist of the construction of a bamboo reinforced concrete pavement on a prepared subgrade.

904.2 Materials

904.2.1 Bedding Sand or Sand Cushion

The sand shall not contain any deleterious impurities nor any clay or silt material and shall comply with the following grading requirements:

Sieve size (mm)	% passing through
9.52	100
4.75	95- 100
2.36	80- 100
1.18	50-85
0.600	25-60
0.300	10-30
0.150	5-15
0.075	0-10

904.2.2 Concrete

(a) Portland Cement

Cement shall confirm to the requirements of AASHTO Standard Specification M85 Type 1, normal Portland cement, or similar approved standard.

Bagged or bulk cement which has partially set or which contains lumps of caked cement shall be rejected. The use of cement reclaimed from discarded or used bags shall not be permitted.

(b) Water

All water used in mixing and curing concrete shall be clean and free from salt, oil or acid, vegetable or other substance injurious to the finished product. The use of river water will be subject to the approval of the Engineer.

(c) Coarse Aggregate

Coarse aggregate for concrete shall consist of hard durable crushed or broken rock. Coarse aggregate shall be clean, free from dust and other deleterious material. If the source of aggregate is proposed to be changed, the Engineer shall be informed in advance and in no case less than 3 weeks before the new aggregate shall be used.

(d) Fine Aggregate

Fine aggregate shall consist of natural sand and have a FM of between 2.00 and 2.50. It shall be clean, free from dust and other deleterious material. Moisture content of fine aggregate shall be determined daily and at any time when a change in moisture content occurs.

904.2.3 Bamboo as Reinforcing Material

This work shall consist of furnishing and placing of bamboo splices as reinforcing material as shown on the drawings. The splices of 1.50-1.80 cm width and 0.5-1.0 cm thickness are considered suitable. The bamboo should be matured for a minimum of 3 years, free from rot or infestation, solid and straight in shape.

The bamboo should be cut and allowed to dry and season for 3-4 weeks and up to 6 weeks before using. All bamboo to be used as reinforcement is to be approved by the Engineer prior to use.

904.2.4 Binding Wire

Bamboo reinforcement binding wire shall be best black annealed mild steel wire, approximately 1.6 mm in diameter.

904.3 Construction Requirements

904.3.1 Sand Cushion

The contractor shall deliver, spread and compact a layer of sand cushion over the existing laterite surface as shown on the drawing and as required by the Engineer.

Immediately after the sand layer has been spread and shaped to camber it shall be thoroughly compacted with mechanical compaction equipment approved by the engineer. The moisture content at the time of compaction shall be the optimum moisture content.

904.3.2 Formwork

Formwork shall include all temporary or permanent moulds for forming the concrete. All formwork shall be of wood or metal and shall be built mortar tight and rigid enough to maintain the concrete in position during placing, compacting, setting and hardening. All forms shall be set and maintained true to the line designed until the concrete is sufficiently hardened and shall remain in place as required by Engineer. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer may order the work stopped until the defects are corrected. If requested, the Contractor shall submit to the Engineer working drawings of the forms. The shape, strength, rigidity, water tightness and surface smoothness of reused formwork shall be maintained at all times. Any warped or bulged timber must be resized before being reused. Formwork that is unsatisfactory in any respect shall not be reused.

904.3.3 Placing Bamboo Reinforcement

The bamboo will be placed 50mm from the top of the pavement. The bamboo mesh of 250 x 250mm will be placed on wooden spacers to ensured the desired 50mm cover to the reinforcement will be maintained. The wooden blocks will be removed as pouring of concrete progresses.

904.3.4 Mixing, Handling and Placing Concrete

Mixers at local site shall be approved drum -type capable of combining the aggregate, cement and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. Suitable equipment for discharging the concrete shall be provided. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity. Retempering concrete by adding water or by other means shall not be permitted. Concrete which is not of the required consistency at the time of placement shall not be used.

Concrete which does not reach its final position in the forms within 10 minutes of completion of mixing shall not be used. When placing operations would involve dropping the concrete more than 1.5m, it shall be deposited through sheet metal or other approved pipes.

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be done by mechanical vibration. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer which has not taken initial set.

Care must be taken to prevent the bamboo reinforcement floating during concrete pouring.

(a) Finishing Concrete Surfaces

Immediately after placing concrete, concrete slabs shall be struck off using templates to provide proper crowns and shall be finished smooth to the correct levels. Finish shall be slightly but uniformly roughened by brooming. The finished surface shall not vary by more than 10 mm from a 3 metre straight edge placed in any direction on the roadway. Deviation from the gradeline shall not be more than +/- 30 mm in any 20 m length.

(b) Joints

All joints shall be made only where shown on the drawings or in the casting schedule, unless otherwise approved by the Engineer.

Joints will be sealed with a bitumen sand mix. A sufficient reservoir of bitumen will be placed at each joint to allow for the effects of movement at the joints.

(c) Curing Concrete

All concrete surfaces shall be kept thoroughly wet for at least 7 days after placing. The road slabs shall be covered with wet Hessian immediately after final finishing of the surface. After a period of 7 days, the concrete shall be watered daily at certain intervals approved by the Engineer to avoid drying out of the surface. This shall take place during the following 2 weeks.

(d) Removal of Formwork

Forms shall not be removed without the approval of the Engineer. Forms used on exposed vertical faces shall remain in place for periods which shall be determined by the Engineer and normally not less than 3 days.

(e) Cleaning Up

Upon completion of roadwork and before final acceptance, the Contractor shall remove all forms. Excavated or useless materials, rubbish etc, shall be removed from the site and the site shall be left in a neat and tidy condition, satisfactory to the Engineer.

904.3.5 Testing

(a) Cement

The Contractor shall notify the Engineer of dates of delivery so that there will be sufficient time for sampling the cement, either at the mill or upon delivery. Any testing ordered by the Engineer shall be carried out at material testing laboratory approved by the Engineer.

(b) Water

The water shall be tested at a recognised laboratory approved by the Engineer. The water shall be tested before commencement of work or any time required by the engineer or if the source is changed.

(c) Aggregates

From the aggregate materials proposed by the contractor samples shall be selected in the presence of the Engineer. The samples shall be brought to the laboratory and tested for proving their conformance with the specifications.

904.3.6 Concrete

(a) The Composition of Concrete

The classes of allowable concrete shall conform to one of the following:

Concrete Class	Minimum concrete Strength (N/mm^2)		Maximum size of Coarse Aggregate (mm)	Minimum cement content (kg/m^3)	Minimum 28 days compressive strength of trial mix (N/mm^2)	
	Cube test	Cylinder test			Cube test	Cylinder test
9	9	7.2	20	250	9	15.2
13	13	10.4	20	285	23	18.4
19	19	15.2	20	340	29	23.2
25	25	20.0	20	385	35	28.0

Note: Cube Test on a 150 mm x150 mm cube sample
Cylinder test on a 150 mm diameter and 300 mm high cylinder
The concrete class quoted in the above table is the 28 day compressive strength

(b) Strength of Concrete

The class of the concrete is shown on the drawings. The class is the specified cube strength at 28 days and shall be determined as indicated in the table above.

(c) Water/ Cement Ratio

The ratio of free water to cement when using saturated surface dry aggregate shall be as low as possible and may vary between 0.45 to 0.50 by weight for all concrete unless otherwise stated.

(d) Workability

The concrete shall be of suitable workability to obtain full compaction. Slumps measured shall not exceed 75 mm ±25 mm unless otherwise directed or approved by the Engineer.

Slump tests shall be carried out regularly during any concreting operations. The minimum frequency should be one slump test at the beginning of each casting and one each time test specimens are taken.

(e) Sampling and Testing of Concrete

The Contractor shall take samples of the concrete for testing. The number, frequency and location shall be decided by the Engineer. A minimum of 3 concrete cubes/cylinders should be taken for each days of casting, or every 15 m^3 of concrete cast in larger pours, and tested at 28 days.

904.4 Measurement and Payment

The unit of measurement for the sand cushion is cubic metre (m^3). The quantity for which payment shall be made shall be product of the instructed thickness, the instructed width and the measured length along the centre line of the road.

The unit of measurement for concrete work shall be cubic metres (m^3). The quantity for which payment shall be made shall be product of the instructed thickness, the instructed average width and the measured length along the centre line of the road.

Item No.	Description	Unit
904.1	Sand Cushion	Cubic metre (m^3)
904.2	Bamboo Reinforced Concrete	Cubic metre (m^3)

Payment will be made at the rates entered in the Bill of Quantities, and shall include for all materials and operations necessary to achieve the finished course to the requirements specified herein.

SECTION 905

GEOCELL SURFACES
LIST OF CONTENTS

905 GEOCELL SURFACES

905.1 Description

The work covered by this section consists of the construction of a concrete block pavement within an in-situ pre-formed plastic formwork termed Geocell.

This work will comprise trial lengths of each of the products as detailed in the drawings.

905.2 Materials

905.2.1 Hyson-Cells Geocell Mattress

The specified Geo Cell paving to be used for these trials is a patented system called Hyson Cells (3D Bubble Lock Cells). Hyson Cells is formwork fabricated from plastic sheeting that is used to cast interlocking concrete block paving in situ. The plastic formwork remains embedded in the concrete.

The source of this patented system material is:

M & S Technical Consultants& Services (Pty) Ltd.
P.O.Box 319
Muldersdrift
1747
South Africa

Tel: +27 (11) 9572478
Fax: +27 (11) 9572547
Email : info@hysoncells.co.za

The products that are to be trials are:

Product code	**Cell Dimension**	**Cell Depth**
300/210x075	150 mm x 150 mm	75 mm
300/210x100	150 mm x 150 mm	100 mm
300/210x150	150 mm x 150 mm	150 mm

905.2.2 Cell Fill

The cells will be filled with either concrete or labour based concrete.

(a) Concrete

(i) Class

The classes of allowable concrete shall conform to one of the following:

Concrete Class	Minimum concrete Strength (N/mm²)	Maximum size of Coarse Aggregate	Minimum cement content (kg/m³)	Minimum 28 days compressive strength of trial mix (N/mm²)

	Cube test	Cylinder test	(mm)		Cube test	Cylinder test
9	9	7.2	20	250	9	15.2
13	13	10.4	20	285	23	18.4
19	19	15.2	20	340	29	23.2
25	25	20.0	20	385	35	28.0

Note: Cube Test on a 150 mm x150 mm cube sample
Cylinder test on a 150 mm diameter and 300 mm high cylinder
The concrete class quoted in the above table is the 28 day compressive strength

(ii) Strength of Concrete

The class of the concrete is shown on the drawings. The class is the specified cube strength at 28 days and shall be determined as indicated in the table above.

(iii) Water/Cement Ratio

The ratio of free water to cement when using saturated surface dry aggregate shall be as low as possible and may vary between 0.45 to 0.50 by weight for all concrete unless otherwise stated.

(iv) Workability

The concrete shall be of suitable workability to obtain full compaction. Slumps measured shall not exceed 75 mm ±25 mm unless otherwise directed or approved by the Engineer. Slump tests shall be carried out regularly during any concreting operations. The minimum frequency should be one slump test at the beginning of each casting and one each time test specimens are taken.

(v) Sampling and Testing of Concrete

The Contractor shall take samples of the concrete for testing. The number, frequency and location shall be decided by the Engineer. A minimum of 3 concrete cubes/cylinders should be taken for each days of casting, or every 15 m^3 of concrete cast in larger pours, and tested at 28 days.

(b) Labour Based Concrete

The Contractor is to assemble special containers for each material type to the satisfaction of the engineer for batching during the mixing of concrete. It is recommended that the containers are of different colours depending on the material that they are to be used for. Rough guidelines of the expected strength of the mix are shown below.

The Ratio of Course aggregate: Fine aggregate: Cement		
1:1:1	2:2:1	4:4:1
50 MPa to 65 MPa	30 MPa to 45 MPa	10 MPa to 25 MPa

The final mix for the site must be determined by trial and following laboratory confirmation, cube strength, a standard then set. A variety of materials and slumps should be tested in order to achieve the best mix. .

905.3 Construction Requirements

905.3.1 Subbase

Prepare subbase to the required level and shape as per the specifications. Note that surface must be smooth as any irregularities in the prepared profile will show on final surface when the cell layer is itself compacted. A "blinding layer" of sand must be laid on the prepared surface as shown on the drawings. This layer will take up any slight irregularities in the levels but the main purpose is that the cells will be embedded in this layer so as to improve the seal between cells and subbase. This is to prevent any of the cement fill from flowing beneath the cell formwork to form an undesirable second un-jointed slab beneath the jointed cell slab.

905.3.2 "Tuck-in" Terminating Anchor Beams

Allow one cell (210 mm) extra material along each side of road for tuck-in of cells into terminating anchor trench as shown on the drawings

Terminating beams run parallel to the road along each shoulder. The excavation for terminating anchorage trenches are to be approximately 200 mm deep and located approximately 200 mm from beginning of shoulder. Trenches should be straight and uniform. .

On steep grades, to prevent possible piping below the road base cut-off beams will be cast across the road at 15 m intervals along the road whenever these piping conditions are suspect. If these cut-offs are specified they must be excavated before the cells are laid. They should be filled with the same fill as the cells. Note that the cells do not tuck in to these transverse cut-off trenches, only into the terminating side trenches

905.3.3 Rigging Hyson-Cells

The plastic formwork is not rigid. It is attached to pegs and tensioned tightly to attain sufficient tautness to be filled with concrete. It is supplied collapsed in 1 m² bags, each module expands to 200 m².

Supply Y10 reinforcing bar for pegging down the cell mattress at a rate of approximately 1 peg per m² for the main area and 1 peg in every second cell in "tuck-in" terminating anchor trenches. The length of each peg varies according to the nature of the in-situ material and may even vary over the site but is commonly "cell depth + 100mm".

The cells must be stretched in the direction of the road and not across the road. The cells must be rigged extremely taut to avoid collapse during filling. The cells must be extended into squares and not parallelograms .

Packs are joined using galvanised pins provided or by utilising strings threaded through alternate cells. Off-cuts and sections may be joined to minimum waste. Anchoring pegs must be driven at least 50 mm below the surface level (top) of the cells.

When a succeeding strip will be laid adjoining the strip currently being laid then the two strips must be joined using a pinning technique described. It is critical that sections are joined and not simply butted alongside each other otherwise a weak construction joint may result.

905.3.4 Placing the Fill

The cells should be slightly overfilled and the fill must be compacted until the top of the cell wall is just visible.

For ready-mix concrete, the truck will traffic the area which has yet to be covered with cells. The truck should deliver the load directly into the cells using a movable chute (with extension if required).

905.3.5 Construction Joints

At the end of a ‘pour’ no cells are to be partially filled. Cells that are partly full cells must be cleaned out using a small trowel.

905.3.6 Compaction

Compacting with vibrating screed beam is preferred but not essential.

905.3.7 Surface Finish

.The surface will be finished with a soft brush to provide good traction and low skid properties for vehicles.

905.3.8 Curing

Cure as per conventional concrete practice.

905.4 Measurement and Payment

The unit of measurement shall be square metres (m²) for each thickness of Geocell as follows:

Item No.	Description	Unit
905.1	75cm thick Geocell Pavement	Square metre (m²)
905.2	100mm thick Geocell Pavement	Square metre (m²)
905.3	150mm thick Geocell Pavement	Square metre (m²)

Payment will be made at the rates entered in the Bill of Quantities, and shall include for Hyson Cell formwork, concrete and all materials and operations necessary to achieve the finished course to the requirements specified herein.

SECTION 906

CONCRETE BLOCK PAVING FOR SURFACES
LIST OF CONTENTS

906 CONCRETE PAVING BLOCKS FOR SURFACES

906.1 Description

This section covers the furnishing of materials and the construction of concrete block paving for roads.

906.2 Materials

906.2.1 Bedding Sand

The bedding sand shall comply the requirements of Section 904.2.1

906.2.2 Jointing Sand

100% of the sand used to fill the joints between the concrete blocks shall pass through a 1.18 mm sieve and between 10% and 15% of it shall pass through a 0.075 mm sieve.

906.2.3 Concrete Paving Blocks

The block shall be of the class, type and thickness specified in the. Project specifications, on the drawings, or in the schedule of quantities. The surface texture and colour of all blocks shall be uniform. The blocks shall comply with the Portland Cement Institute's abrasion test.

The specification requires that pavers comply with certain tolerances, and have a compressive strength of 25 MPa, for lightly trafficked situations, or 35 MPa, for more severe conditions or where a wheel load greater than 30 kN is encountered.

(a) Cement

The Contractor shall notify the Engineer of dates of delivery so that there will be sufficient time for sampling the cement, either at the mill or upon delivery. Any testing ordered by the Engineer shall be carried out at material testing laboratory approved by the Engineer.

(b) Water

The water shall be tested at a recognised laboratory approved by the Engineer. The water shall be tested before commencement of work or any time required by the engineer or if the source is changed.

(c) Aggregates

Natural aggregates used in the manufacture of concrete paving blocks should meet the requirements for aggregates for concrete given in these specifications. The performance of aggregates at the moulding stage and in the hardened block depends on the combined effects of particle size, grading, particle shape, and hardness. Each of these properties is given below.

The maximum nominal size of aggregate is 13.2 mm, the aggregate shall comply with the following grading:

Sieve size (mm)	% passing through
13.2	100
9.5	90-100
4.75	70-85
2.36	50-65
0.300	10-25
0.150	5-15
0.075	2-10

906.3 Construction Requirements

906.3.1 Underlying Pavement Layers

The underlying pavement layers shall be constructed and prepared in accordance with the requirements for the relevant pavement layers, the project specifications and the drawings.

906.3.2 Bedding Sand

A layer of bedding sand shall be placed on top of the prepared surface of the underlying pavement layer. This layer shall be accurately levelled to an uncompacted thickness as shown on the drawings so that the concrete paving blocks will have the correct level after compaction. The bedding sand shall be placed immediately before the concrete paving blocks are laid and shall not be compacted before the blocks have been laid.

906.3.3 Concrete Paving Blocks

The blocks shall be laid in the pattern shown on the drawings or as directed by the engineer. Unbroken blocks shall be laid first and the filler pieces afterwards. Filler pieces shall be neatly sawn or hewn to fit exactly into the space to be filled. Any space of which the size is less than 25% of the size of an unbroken block, shall be filled with 35 MPa concrete. The size of the joints between blocks shall be between 2 mm and 4 mm, and the top faces of the blocks shall be flush.

After the paving blocks have been laid, the pavement shall be compacted to bed in the paving blocks.

After compaction of the pavement as described above, jointing sand shall be spread and brushed into the joints until the joints have been properly filled. Any surplus sand shall then be broomed off and the pavement shall then be subjected to two further passes by the plate vibrator.

906.3.4 Edge Beams and Intermediate Beams

Cast in situ or prefabricated concrete edge beams or intermediate beams shall be constructed on the underlying pavement layer in accordance with the details shown on the drawings. No paving blocks shall be laid before the edge and intermediate beams have developed sufficient strength to withstand the construction forces.

906.3.5 Construction Tolerances

The completed concrete block paving shall comply with the following construction tolerances:

Maximum deviation from any 3 m straight line	10 mm
Maximum deviation from any 20 m straight line	20 mm
Vertical deviation from 3 m straight-edge	±10 mm
Maximum difference in the surface levels of adjacent units	5 mm

906.4 Measurement and Payment

The unit of measurement for concrete block pavement shall be the square metre of completed concrete block paving. The quantity shall be calculated from the dimensions shown on the drawings or authorized by the engineer.

The tendered rate shall include full compensation far furnishing all materials, constructing the sand bedding, laying and compacting the concrete pavement blocks, filling the joints with jointing sand, and for all other work necessary to complete the concrete beck paving as specified.

The unit of measurement for the cast in situ edge beam shall be the cubic metre of concrete in edge and intermediate beams. The quantity shall be calculated from the dimensions shown on the drawings or authorized by the engineer.

The tendered rate shall include full compensation for furnishing all materials, and constructing the edge and intermediate beams complete as specified, including all excavation and backfilling in all classes of material.

Item No.	Description	Unit
906.1	Bedding Sand	Cubic metre (m^3)
906.2	Concrete Block Paving	Square metre (m^2)
906.3	Cast in situ Concrete Edge and Intermediate Beams	Cubic metre (m^3)

Payment will be made at the rates entered in the Bill of Quantities, and shall include for all materials and operations necessary to achieve the finished course to the requirements specified herein.

SECTION 907

HAND PACKED STONE
LIST OF CONTENTS

907 HAND PACKED STONE

907.1 Description

This work shall consist of the supply, shaping, packing and compaction of a pavement course composed of stones packed on a prepared subgrade and within prepared and compacted shoulders with the Specifications and to the lines, levels, dimensions and cross-falls shown on the Drawings or as directed by the Engineer.

907.2 Materials

907.2.1 Stone

The stones shall be sharp and angular of approximately cubical in size and shall be hard and durable to serve as ideal material for stone packing pavement. The stones shall be free from vegetation, soft particles and excess clay or any other substance, which is considered deleterious.

The stone shall comply with the following requirements:

(i) Water absorption shall not exceed 2%.

(ii) Los Angeles Abrasion value shall be not more than 30 (BS 812) or as directed by the Engineer. Specific Gravity not less than 2.0

(iii) Plasticity Index of binding materials shall not more than 6.

(iv) FM of sand shall not be less than 2.0 and shall be free from deleterious materials.

Coarse aggregate to pack the stone shall be of the same material as stone blocks.

Screenings to fill voids shall be consists of coarse sand. The liquid limit and plasticity index shall be 20 and 6 respectively and fraction passing 0.075 mm sieve does not exceed 5%.

907.2.2 Cushion Material

Materials for the sand cushion shall consist if coarse sand of FM (Fineness Modulus) not less than 2.0. The liquid limit and plasticity index shall be 20 and 6 respectively and fraction passing 0.075 mm sieve does not exceed 5%.

907.3 Construction Requirements

907.3.1 Preparation of Foundation

The subgrade to receive the sand cushion shall be prepared to the required grade and camber and cleaned of all dust, dirt and other extraneous matter. Weak places shall be strengthened, corrugation removed, depressions and pot holes made good with suitable materials before spreading the sand.

907.3.2 Shoulders Construction

Side shoulders shall be constructed in advance to a thickness corresponding to the compacted layer of the stone packing pavement and due to the drawings. The shoulders shall be compacted to a dry density of at least 95% MDD (AASHTO, Modified Proctor).. After the shoulders are ready, their inside edges shall be trimmed vertical.

907.3.3 Spreading of Sand Cushion

The coarse sand shall be spread uniformly upon the prepared subgrade in such quantities that the thickness of compacted layer is 50 mm. In no cases shall these be dumped in heaps directly on the area where these are to be laid. The relationship between the loose thickness and compacted thickness shall be determined from field trials and used in controlling the loose thickness at the time of spreading the materials.

907.3.4 Compaction

Immediately following the spreading of coarse sand, it is first rolled dry with aid of a 0.8 to 1.0 ton roller until the layer has been firmly compacted. Slightly sprinkling of water may be done during rolling, if required. Rolling should not be done if the subgrade is soft or yielding. The rolled surface shall be checked transversely and longitudinally with templates and if the irregularities exceed 12 mm, the surface should be loosened and aggregate added or removed before rolling again. In no case shall the use of screenings be permitted to make up depressions.

907.3.5 Placing and Packing Stones

Stones shall be laid so that each block is settled on the sand cushion without any support from the blocks nearby and with an average space of 5-15mm between blocks. The voids between the stones shall then be filled with broken stones packed in with proper tools. A regular top surface should be achieved during the laying operation. The stones shall be placed to the required grades and camber. A camber board shall be used longitudinally and across the section to assure an even surface.

After packing the gaps with broken stones, sand shall be spread and gently washed and brushed into the voids between the stones. Water tanks shall not be utilized for this operation.

907.3.6 Compaction

A vibrating roller or a plate compactor shall be used. Compaction should be carried out to level the height of the stone blocks, providing a smoother running surface on the carriageway. Compacting shall be carried out from the edge to the centreline of the road to avoid extra stress on the shoulders.

907.4 Measurement and Payment

This work shall be measured as the volume in cubic metres of hand packed stone compacted and accepted. Area shall be computed from field measurement of the width of the course at its top surface and the nominal depth as shown in the Drawing or as ordered by the Engineer.

Item No.	Description	Unit
907.1	Sand Cushion	Cubic metre (m^3)
907.2	Stone Packing	Square metre (m^2)
907.3	Continuous Filter Drains	Cubic metre (m^3)

Payment will be made at the rates entered in the Bill of Quantities, and shall include for all materials and operations necessary to achieve the finished course to the requirements specified herein.

SECTION 908

HAND PACKED STONE (MORTARED STONE)
LIST OF CONTENTS

908 HAND PACKED STONE (MORTARED STONE)

908.1 Description of Work

This work shall consist of the supply, shaping and compaction of a pavement course composed of stones with mortared joints on a prepared subgrade and within prepared and compacted shoulders with the Specifications and to the lines, levels, dimensions and cross-falls shown on the Drawings or as directed by the Engineer.

908.2 Materials

908.2.1 Stone

The stone shall comply with that specified in Section 907.

908.2.2 Cushion material

Materials for the sand cushion shall comply with Section 907.

908.2.3 Mortar

Mortar ingredients shall conform to the requirements for Portland cement, admixtures and water of Section 507, masonry cement to ASTM C91 and sand aggregate to AASHTO M45.

The proportions shall be such that the volume of sand in a damp loose condition is between two to three times the volume of cementitious materials. The cementitious materials shall consist of one part Portland cement to between one and two parts of masonry cement. Pre-mixed materials conforming to these requirements may be used.

908.3 Construction Requirements

908.3.1 Preparation of Foundation

The subgrade to receive the sand cushion shall be prepared to the required grade and camber and cleaned of all dust, dirt and other extraneous matter. Weak places shall be strengthened, corrugation removed, depressions and pot holes made good with suitable materials before spreading the said.

908.3.2 Shoulders Construction

Side shoulders shall be Construct in advance to a thickness corresponding to the compacted layer of the stone packing pavement and due to the drawings. The shoulders shall be compacted to a dry density of at least 95% MDD (AASHTO, Modified Proctor). After the shoulders are ready, their inside edges shall be trimmed vertical.

908.3.3 Spreading of Sand Cushion

The coarse sand shall be spread uniformly upon the prepared subgrade in such quantities that the thickness of compacted layer is 50 mm. In no cases shall these be dumped in heaps directly on the area where these are to be laid. The relationship between the loose thickness and compacted thickness shall be determined from field trials and used in controlling the loose thickness at the time of spreading the materials.

908.3.4 Compaction

Immediately following the spreading of coarse sand, it is first rolled dry with aid of an 0.8 to 1.0 t roller until the layer has been firmly compacted. Slightly sprinkling of water may be done during rolling, if required. Rolling should not be done if the subgrade is soft or yielding. The rolled surface shall be checked transversely and longitudinally with templates and if the irregularities exceed 12 mm, the surface should be loosened and aggregate added or removed before rolling again. In no case shall the use of screenings be permitted to make up depressions.

908.3.5 Placing Stones

Stones shall be laid so that each block is settled on the sand cushion without any support from the blocks nearby and with an average space of 5-15mm between blocks. A regular top surface should be achieved during the laying operation. The stones shall be placed to the required grades and camber. A camber board shall be used longitudinally and across the section to assure an even surface.

908.3.6 Mortar

The mortar shall be hand mixed or machine mixed. In preparation of hand mixed mortar, the sand and cement shall be thoroughly mixed together in clean, tight mortar box until the mixture is uniform in colour, after which clean water is added in such a quantity to form a stiff plastic mass. Machine mixed mortar shall be mixed not less than 3 minutes nor more than 10 minutes. Mortar shall be used within 1.5 hours after mixing. Re-tempering of mortar shall be done as necessary to maintain proper consistency during placement.

908.4 Measurement and Payment

This work shall be measured as the volume in cubic metres of hand packed stone compacted and accepted. Area shall be computed from field measurement of the width of the course at its top surface and the nominal depth as shown in the Drawing or as ordered by the Engineer.

Item No.	Description	Unit
907.1	Sand Cushion	Cubic metre (m^3)
907.2	Mortared Stone	Square metre (m^2)
907.3	Continuous Filter Drains	Cubic metre (m^3)

SECTION 909

QUALITY CONTROL AND MONITORING
LIST OF CONTENTS

909 QUALITY CONTROL AND MONOTORING

909.1 Testing

Testing shall be carried out in accordance with Vol.3 Part B General Specifications Section 105 Testing and Control..

909.2 Monitoring

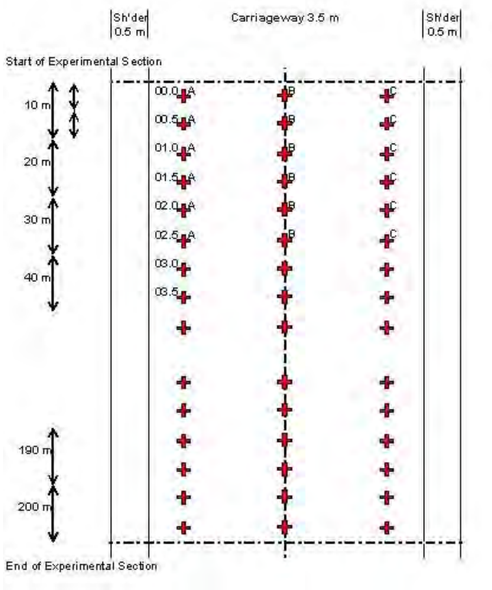
In order to determine the performance of the rural assess roads the following method of monitoring will be carried out.

909.2.1 <u>Location of the Trial Sections</u>

The location of the trial sections are to be identified by the Engineer. They will comprise of a section at least 200 m long with a 100 m long training section prior to the trial length. The lengths of the sections may differ depending on the decision of the Engineer.

909.2.2 <u>Pre Construction Monitoring</u>

Once the subgrade has been constructed to the satisfaction of the Engineer a series of DCP tests should be conducted in a grid as follows.

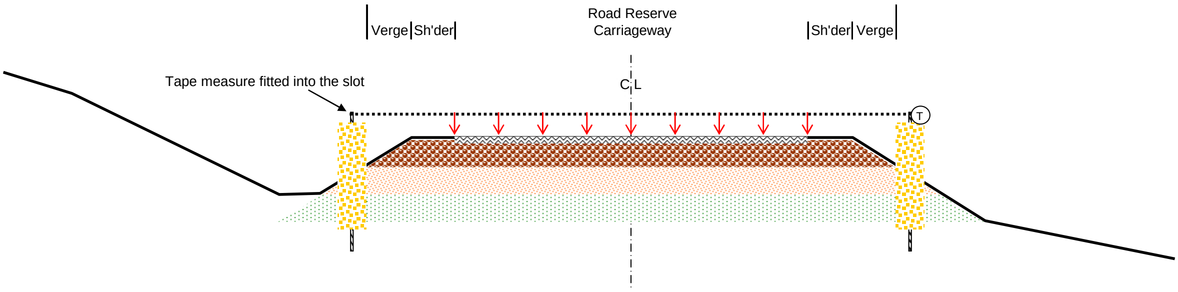


909.2.3 <u>Construction of Beacons</u>

Beacons must be constructed along the Trial Lengths in the locations as directed by the Engineer. The beacons should be constructed as shown on the drawings.

Thus the trial section is divided up into 'Blocks' for monitoring, each Block can be described and any distress graphically represented by sketches and photographs. The format of this will be finalised during the construction of the trial lengths. A method of measuring the rutting and surface deformation is to be conducted by 'dipping' from a line between the beacons as follows.

Method of Dipping from Reference Beacons to Define the Road Surface



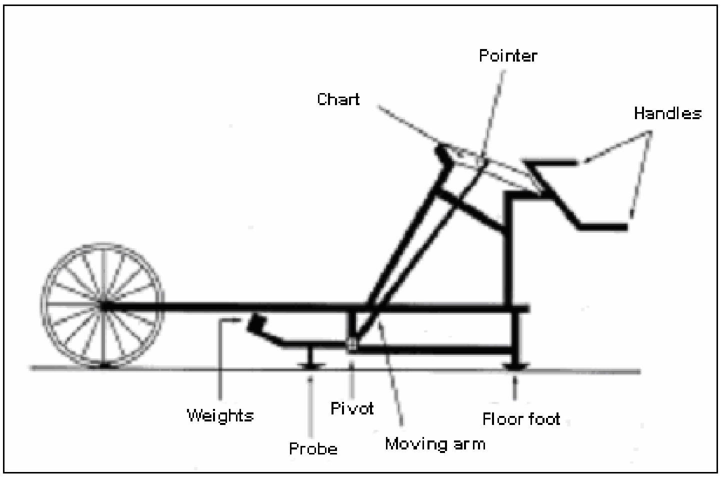
909.2.4 Method of Monitoring

The proposed monitoring to be conducted twice yearly, before and after the rainy season, is as follows:

- Visual inspections including sketches and photographing each Block;
- Surface profile measurement between beacons;
- Surface rut measurement using a standard straight edge;
- Roughness measurement using a MERLIN;
- Surface texture testing (sand patch), as necessary;
- Monitoring using the Keros Prima 100 Portable FWD, as necessary.

909.2.5 Monitoring Equipment

Deterioration of the road surface along the trial sections will be measured in terms of surface roughness. The standard measure of roughness is the International Roughness Index (IRI) which will be determined using the MERLIN.



The MERLIN can be produced locally in accordance with the drawing provided in the bid documents.

Prima Falling Weight Deflectometer

Deflection tests will be carried out on the trial sections using a Falling Weight Deflectometer.

The Keros Prima 100 Portable FWD can be obtained from:

Dynatest
Naverland 32
DK-2600 Glostrup, Denmark

Tel: +45 7025 3355
Fax: +45 7025 3356

Email: denmark@dynatest.com

Appendix 7

Cost Estimates

Bill No 900 PAVEMENT TRIALS

Gravel Pavement Layers

Item No.	Description	Unit	Quantity	Rate (Kip)	Amount (x 000 Kip)
902.1	Selected Subgrade:				
	Type 1				
	Type 2				
	Type 3				
902.2	Subbase:				
	Type 1	cu.m	494	10,400	5,137,600
	Type 2	cu.m	1,117	62,400	69,700,800
	Type 3				-
902.3	Base:				-
	Type 1				-
	Type 2				-
	Type 3	cu.m	617	166,400	102,668,800
902.4	Shoulder and Wearing Course	cu.m			
902.5	Chemical stabilisation extra over unstabilised compacted layers	cu.m	350	12,064.00	4,222,400
902.6	Chemical Stabilising Agent	Tonne	14	728,000	10,319,400

Bituminous Surfaces

Item No.	Description	Unit	Quantity	Rate (Kip)	Amount (x 000 Kip)
903.1	Prime Coat	litre	2,126	7,696	16,361,696
903.2	Application of tack coat:				-
(i)	MC-70 cut-back bitumen,				-
(ii)	MC-3000 cut-back bitumen,	litre	3,412	8,216	28,032,992
(iii)	Spray-grade emulsion (65% net bitumen),				-
(iv)	Spray-grade cationic emulsion (70% net bitumen),				-
(v)	150/200 penetration grade bitumen.				-
903.3	Sand	cu.m.	24	96,720	2,321,280
903.4	Single Otta Seal using:				-
(i)	150/200 penetration grade bitumen				-
(ii)	MC 3000 cutback bitumen viscosity grade	sq.m.	2,450	17,009	41,672,540
(iii)	MC 800 cutback bitumen viscosity grade				-
903.5	Variations in bituminous binder in:				-
(i)	150/200 penetration grade bitumen				-
(ii)	MC 3000 cutback bitumen viscosity grade (PQ)	litre	100	8,216	821,600
(iii)	MC 800 cutback bitumen viscosity grade				-
(iv)	Power paraffin	litre			-
903.6	Variations in anti-stripping agent				-
903.7	Variations in aggregate:				-
(i)	Otta Seal (PQ)	cu.m.	5	202,800	1,014,000
(ii)	crusher dust				-
(iii)	sand				-
903.8	Sweeping back dislodged aggregate into the wheel tracks, as directed by the Engineer	included			-

Item No.	Description	Unit	Quantity	Rate (Kip)	Amount (x 000 Kip)
903.9	Attending to areas of fattiness and bleeding by applying fine aggregates or sand	included			-
903.10	Sweeping back dislodged sand into the wheel tracks, as directed by the Engineer	included			-
903.11	Supply and mixing of power paraffin for cutting back bitumen				-
903.12	Supply and mixing of anti-stripping agent	included			-

Bamboo Reinforced Concrete

Item No.	Description	Unit	Quantity	Rate (Kip)	Amount (x 000 Kip)
904.1	Sand Cushion	cu.m.	41	96,720	3,965,520
904.2	Bamboo Reinforced Concrete				-
i	125mm thick	cu.m.	164	908,000	148,912,000
ii	150mm thick	cu.m.	105	904,000	94,920,000

Geocells

Item No.	Description	Unit	Quantity	Rate (Kip)	Amount (x 000 Kip)
905.1	75cm thick Geocell Pavement	sq.m.	700	146,518	102,562,873
905.2	100mm thick Geocell Pavement	sq.m.	350	186,268	65,193,910
905.3	150mm thick Geocell Pavement	sq.m.	350	265,690	92,991,658

Concrete Paving Blocks

Item No.	Description	Unit	Quantity	Rate (Kip)	Amount (x 000 Kip)
906.1	Bedding Sand	cu.m.	35	96,720	3,385,200
906.2	Concrete Block Paving	sq.m.	1,750	230,672	403,676,000
906.3	Cast in situ Concrete Edge Beams	cu.m.	4	884,000	3,536,000

Hand Packed Stone

Item No.	Description	Unit	Quantity	Rate (Kip)	Amount (x 000 Kip)
907.1	Sand Cushion	cu.m.	35	96,720	3,385,200
907.2	Stone Packing	sq.m.	1,750	291,200	509,600,000

Mortared Stone

Item No.	Description	Unit	Quantity	Rate (Kip)	Amount (x 000 Kip)
907.1	Sand Cushion	cu.m.	42	96,720	4,062,240
907.2	Mortared Stone	sq.m.	2,100	395,200	829,920,000

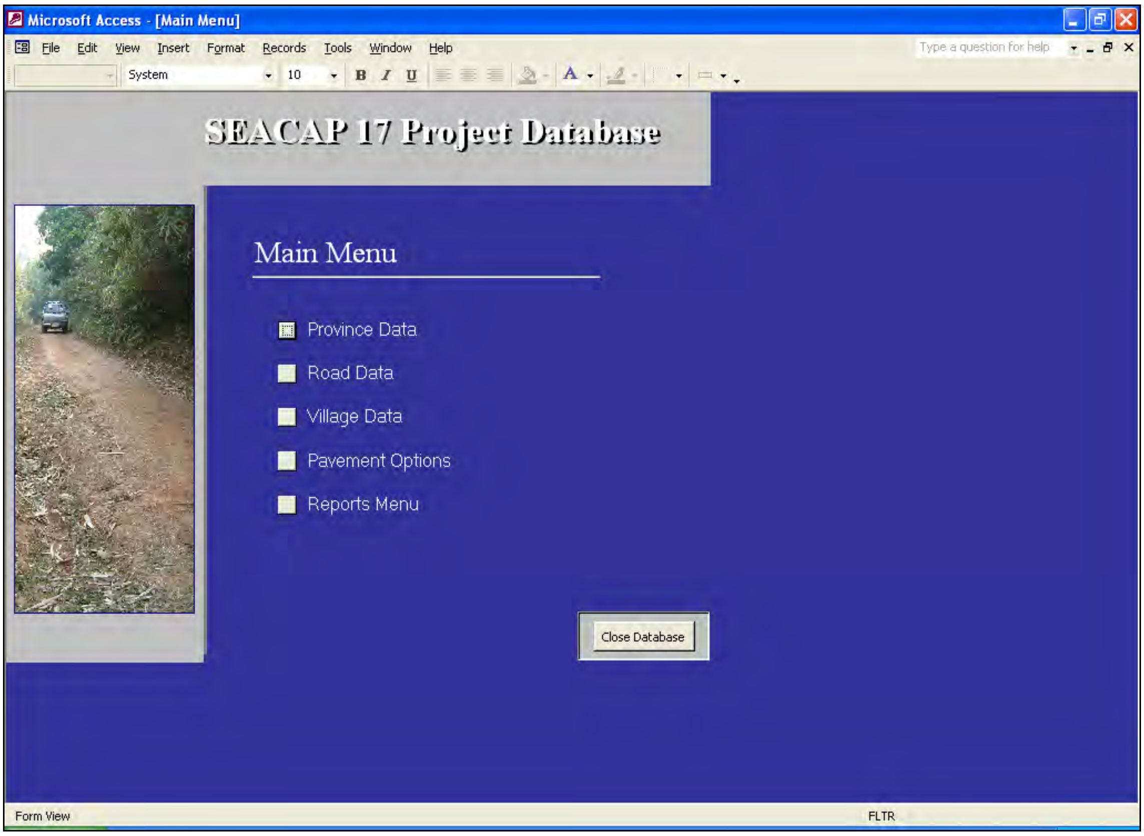
Monitoring

Item No.	Description	Unit	Quantity	Rate (Kip)	Amount (x 000 Kip)
907.1	Monitoring Beacon	Nr	770	57,200	44,044,000
907.2	MERLIN Road Roughness Equipment	Nr	1	4,160,000	4,160,000
907.3	Prima Falling Weight Deflectometer	Nr	1	144,498,640	144,498,640

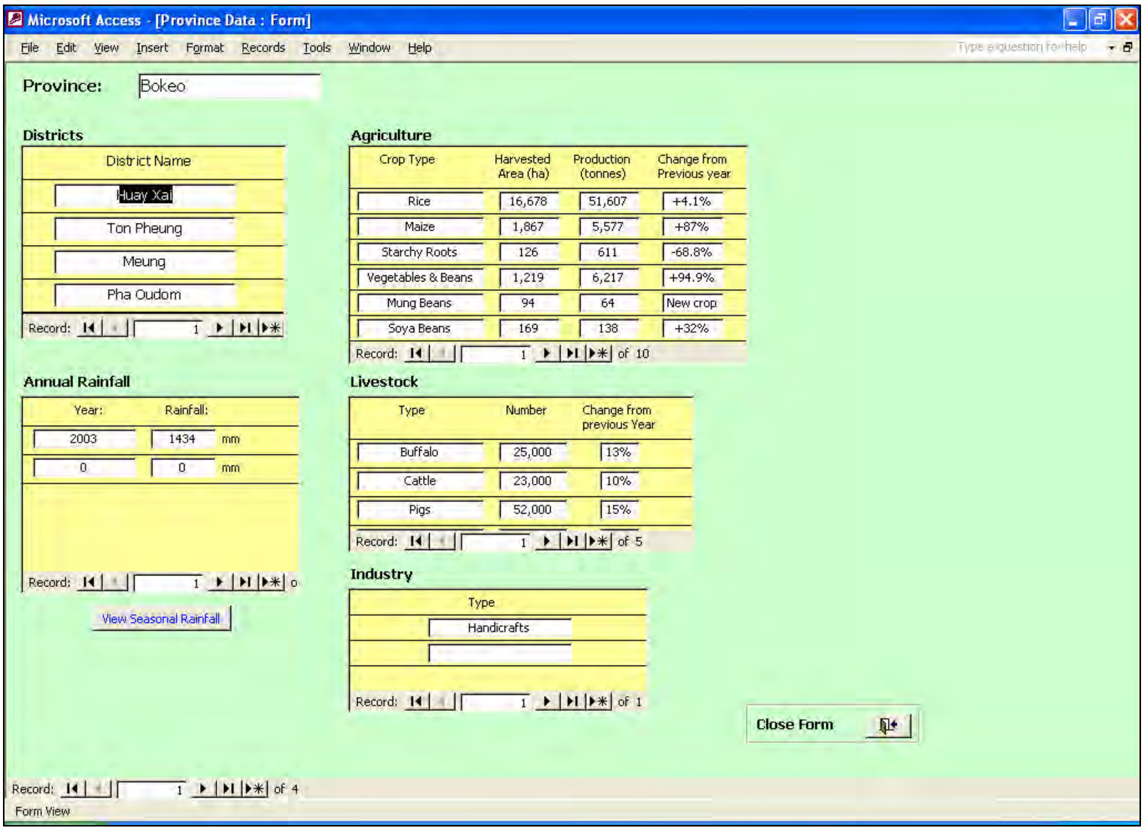
Total Kip	2,741,086,350
Total US$	263,566.00

Appendix 8

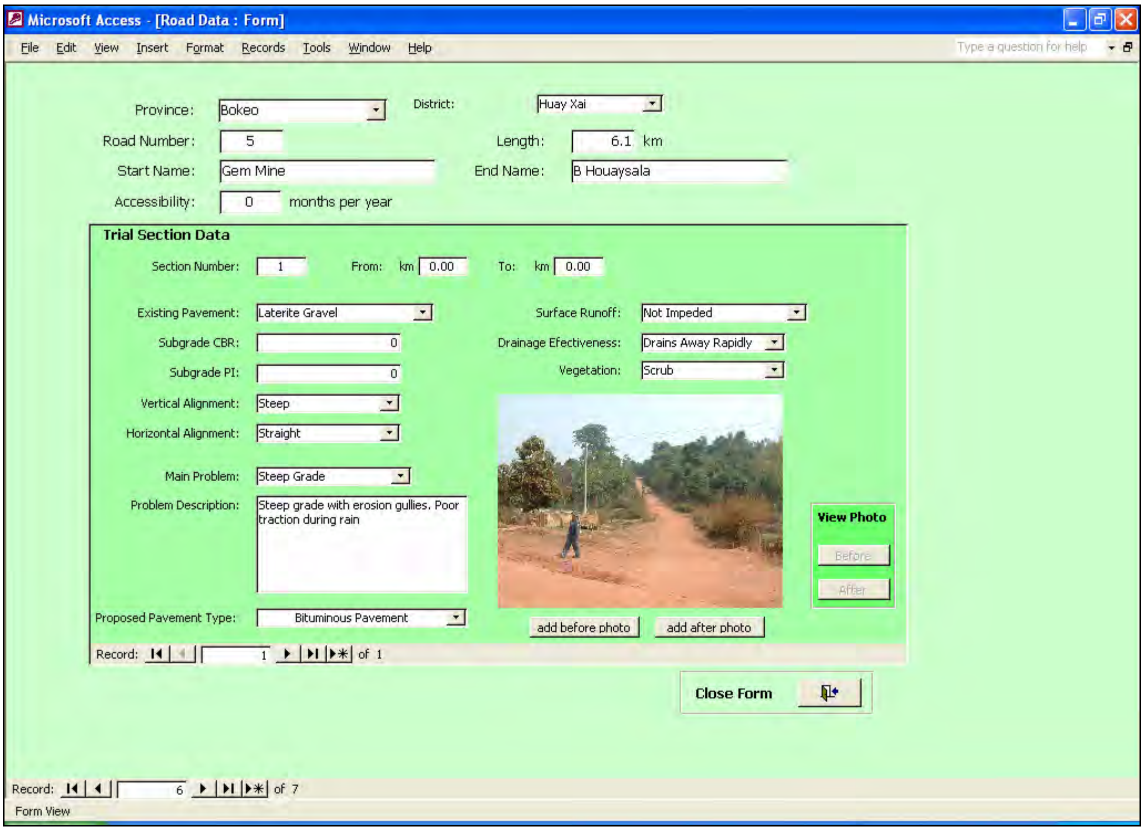
Project Database



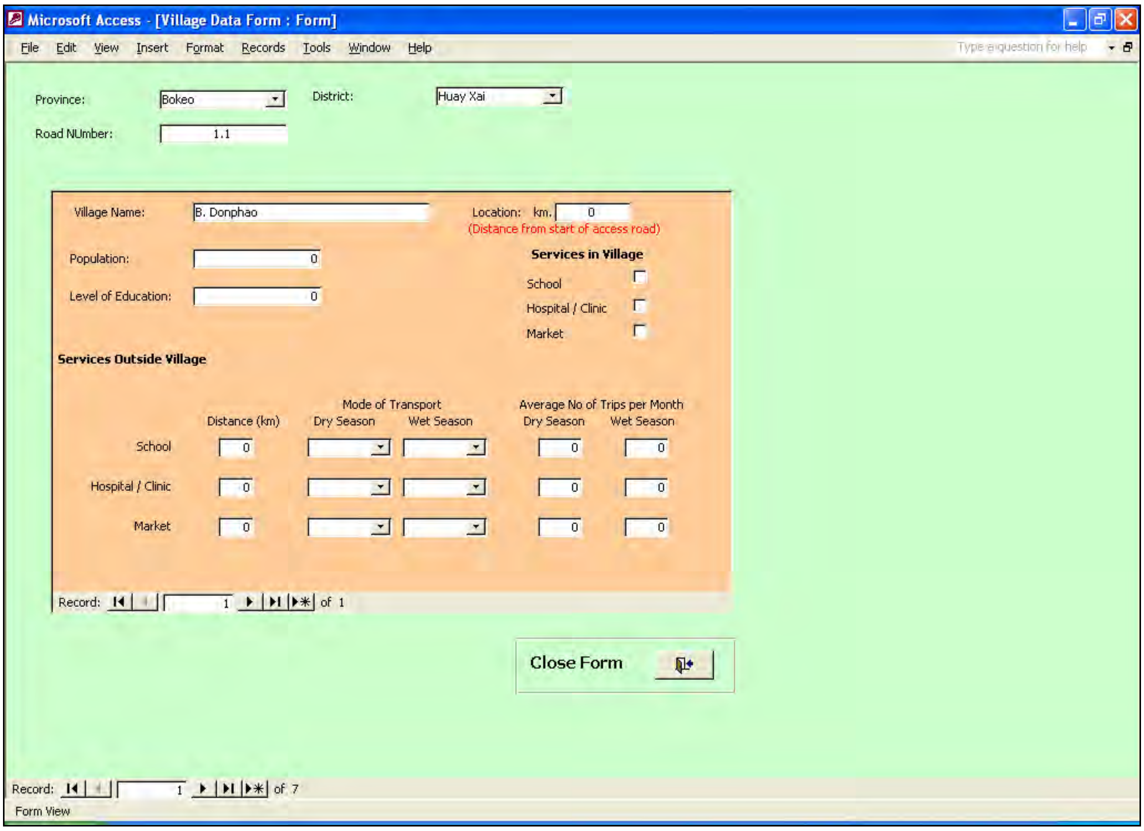
Main Menu



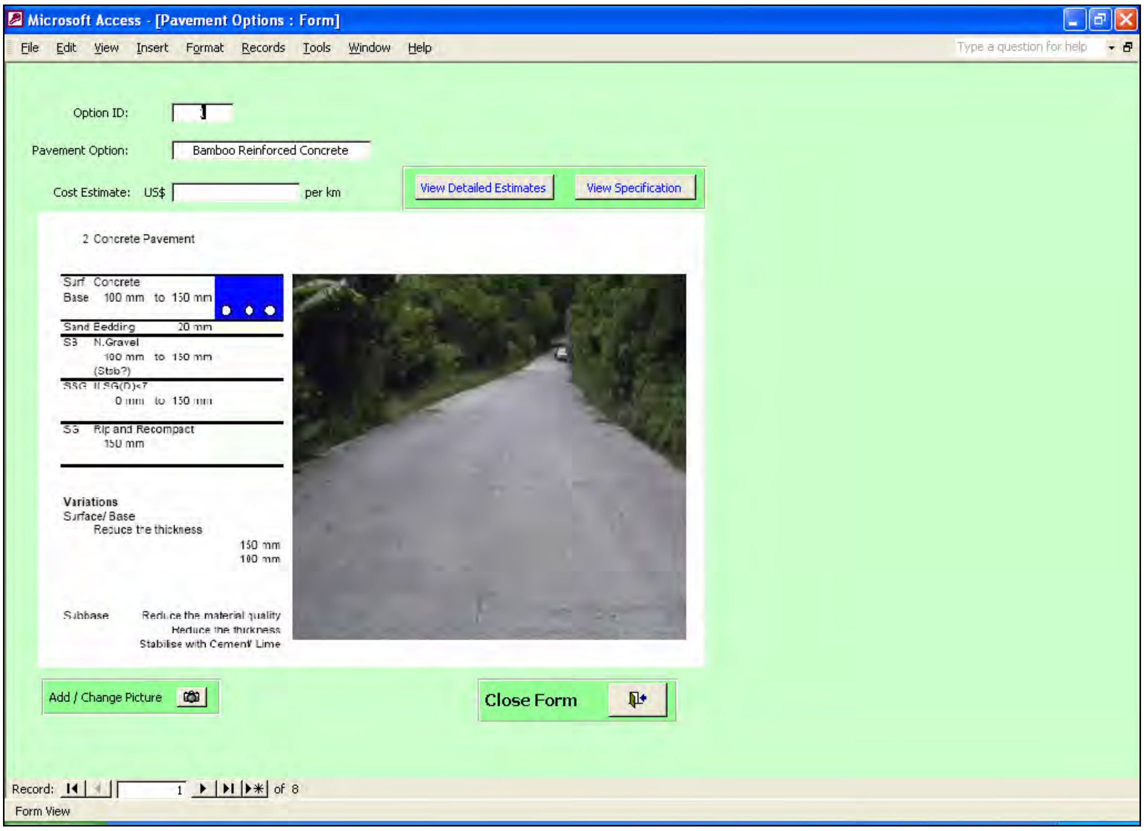
Province Data Screen



Road Screen



Village Data Screen



Pavement Options Screen

Appendix 9

Knowledge Exchange Workshop

LAO PEOPLE'S DEMOCRATIC REPUBLIC
Peace Independence Democracy Unity Prosperity

Ministry of Communication, Transport, Post and Construction

Report on The SEACAP 17 Knowledge Exchange Workshop

Vientiane
15 – 16 December 2004

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Appendices

1 INTRODUCTION

1.1 The SEACAP 17 Project

SEACAP

SEACAP is a rural transport research, dissemination and uptake programme with the objective of supporting the uptake of low cost, sustainable solutions for rural access. While initial SEACAP projects have focussed on Vietnam and Cambodia, the benefits of including Lao PDR become obvious with the country witnessing an increase in transport investment and development activity in the last five years and facing similar issues of raising costs, maintenance and difficulty of providing cost effective and sustainable access to remote communities.

The ADB, the World Bank and the Swedish Development Agency (SIDA) have been actively involved in funding road transport rehabilitation and maintenance projects in the country. Each international donor has a rural road programme that focuses on specific roads or provinces with a set common themes i.e. problem identification, community participation and knowledge transfer.

The ADB will fund the rehabilitation of Route 3 as part of its Northern Economic Corridor Project (NEC Project). Owing to the topography of Route 3 in Northern Lao PDR, it was proposed that the feeder roads/access roads of Route 3 would be appropriate for inclusion in SEACAP particularly as the ADB funded portion of the NEC Project includes such access roads that link the Route 3 with the outlying villages.

SEACAP 17

As part of its SEACAP, DFID intends to work with the MCTPC, to determine and disseminate best practice and appropriate road technologies for the construction and maintenance of rural roads. The SEACAP Project will aim to identify cost-effective community orientated approaches for improving all year access to remote rural areas through a low-cost and local resource based improvement of roads in Lao PDR.

The research will explore:

- The use of domestically produced cement either to stabilise the locally occurring materials or as cement-concrete in the road pavement for problematic lengths of road, rather than using imported bitumen based products in traditional surfacing.
- Other options for pavement surfacing that are locally available and offer low cost solutions.

The use of bio-engineering to stabilise susceptible roadside slopes and improve drainage structures.

These alternatives will be tested by way of trial sections on the access roads linking Route 3 with the outlying villages/towns. The research and recommendations on appropriate road surfacing will analyse the viability of different options that have found applications elsewhere in South East Asia and could be applied in the context of Lao PDR.

The SEACAP Project also aims to disseminate the results of the surface trials within government organisations and national practitioners. This is expected to contribute to the mainstreaming of the technology into government standards and specifications.

1.2 The Workshop

Organisation

The Knowledge Exchange workshop was held with two distinct purposes. First to introduce SEACAP and the SEACAP 17 project to the staff and consultants of MCTPC. The second and main objective was to share experiences from projects within Laos PDR and from the SE Asia region and worldwide.

The workshop was held at the Ministry of Communication, Transport, Post and Construction in Vientiane on the 15th and 16th December 2004.

Participants

The participants represented a cross section of local and international delegates.

From within MCTPC, participants included the heads and staff of the different divisions within the Department of Roads and from other departments that had a direct interest in the implementation of rural access infrastructure. In addition, international consultants working on projects for MCTPC were also represented including those of the ADB NEC project, Lao-Swedish Road Sector Project B and SEACAP 17.

International participants included Halcrow, appointed by DfID to manage the technical aspect of the SEACAP programme, Intech and TRL, both of whom are conducting research into rural access roads worldwide, and the Institute of Transportation Science and Technology in Vietnam.

2 PROCEEDINGS

2.1 Workshop Opening

The workshop commenced at 9.00 a.m. on the 15th December with registration of the participants.

The chairman of the Workshop was My Viengsavath Siphandone, Director General of the Department of Roads. Mr Somnuk Mektakul, Deputy Director Local Road Division, acted as the workshop facilitator.

The workshop was officially opened by Mr Viengsavath. In his address Mr Viengsavath welcomed the participants and gave his thanks to DfID for sponsoring the research project. He added his wish that the workshop would produce fruitful discussions between the international experts and local engineers and declared the workshop open.

Mr Peter O'Neill was then asked to make a welcoming address to the workshop. In his address Mr O'Neill started by describing the SEACAP programme and outlining its goals and how they could be achieved. The current focus in Vietnam, Cambodia and Lao PDR is to provide existing and new knowledge on which to base decisions on rural transport. He went on to describe the funding and management arrangements, in particular the role of Crown Agents and Halcrow as the agents of DfID for the SEACAP programme. He concluded by listing some of the achievements of the programme what is on the drawing board for future project.

2.2 Presentations

The following is a brief summary of the presentations given throughout the workshop.

2.2.1 Introduction to SEACAP 17 – Lao PDR

The SEACAP Working Mechanism; P Caine Halcrow Group

Mr Caine gave an overview of the SEACAP programme in Vietnam and Cambodia explaining its goal to support low cost solutions for rural access. He added that there are at present 17 projects throughout South East Asia and that the programme can be extended here opportunities arise. These opportunities can be identified by DfID or its agents or by individual countries. He concluded by outlining the process for adding new projects and the for the procurement of consultants.

Introduction to SEACAP 17; M James Roughton International

Mr James gave a presentation to introduce the SEACAP 17 project. He started by providing the background to the project and the collaboration between MCTPC, DfID and the ADB to provide the mechanism for the research under the ADB NEC Project. He then highlighted the research aspects of the project, detailing the existing problems being encountered on access roads and the aims and objectives of the research in finding solutions to these problems. He then proceeded to explain the implementation of the research in 4 separate modules through the construction programme of the NEC project, explaining in detail the proposed relationship between SEACAP, ADB and MCTPC.

Trial Pavement Engineering; SD Gillette Roughton Interntional

Mr Gillett started by explaining that while there has been talk of alternative surfacing, in fact we are looking at pavement structures rather than just the surface. He continued by describing the basic concepts and criteria for the different layers of the pavement structure and the factors to be considered during pavement design. These include the various locations to be considered for the trials including flat swampy areas and steep gradients and where the different pavement types would be utilised. The alternative pavement types, numbering 38 in total, were presented in detail. He concluded by describing the monitoring process, which is a key aspect of the trials in determining the performance and relative successes of the different trial pavements.

2.2.2 Experiences from the Region

Surfacing Research in South East Asia; R Petts Intech Associates

Mr Petts presented the findings of research carried out to date in Africa and South East Asia. The key message in his presentation was that there is an unsustainable reliance on gravel roads for access to poor rural communities and that a new approach is required using more durable low lost local resource based materials. He then went on to detail the situations where gravel is not the most appropriate pavement material and describe proven alternative pavement construction types being tested in Vietnam and Cambodia. He outlined various considerations for the selection of pavement types and the issues involved in conducting the trials and monitoring the results. He concluded by listing the advantages and disadvantages of the various pavement options and the challenges in the control of bitumen and concrete works.

Natural Gravels in Vietnam, Low Volume Rural Road Pavements; Dr J Cook TRL

Dr Cook started his presentation by describing the different aspects of the road environment and those prevailing in Vietnam, including the geology, rainfall, traffic and material quality. He then gave a summary of the type of deterioration, including gravel loss and erosion and went on to describe the TRL and ARRB approaches to pavement design, explaining the key issues relating to design, construction maintenance and drainage. He continued by explaining that standards must be appropriate and be realistic and achievable, quoting the Vietnam current specifications and the technical constraints in meeting their requirements. He concluded by mentioning the possibilities of staged and composite construction.

Experiences from Low Cost Surfacing Trials; H Kackada, Intech Associates

Mr Kackada started his presentation with an overview of the Low Cost Surfacing Project (LCS), explaining the criteria for justifying road investment and the benefits of the LCS options, with examples from China and Cambodia. He went on to explain the different pavement options used for the trials together with cost breakdowns and pavement testing and analysis methods. The results of the trials show that good quality pavements can be constructed using labour based methods and almost all the trial sections had low maintenance and high residual value. He then introduced the problems of overloading detailing the key issues and giving examples and solutions from Cambodia

2.2.3 Experiences of Rural Access in Lao PDR

Experience of Rural Access in Laos; Ounheuane Siriamphone MCTPC

Mr Ounheuane gave a presentation on the rural road network in Lao PDR. He gave the background of the road network explaining the limitations of gravel quality, environment and budgetary constraints. A summary of the road construction showed the distribution of paved, gravel and earth roads among the different road classifications. He then summarised the recent ADB funded projects and their component roads, including the forthcoming ADB 10 project. He concluded with some observations on the experiences from the ADB project.

Experiences from the ADB 8 Project; Emilian Roy

Mr Roy gave a spoken presentation on the experiences from the Xieng Khaoung Road Improvement Project, funded by the ADB. He started by outlining the design approach and the various aspects of the specification, including the testing programme. He went on to explain the problems encountered during construction of the access roads and the factors taken into account for the design criteria. He summed up by giving the advantages and disadvantages of the gravel pavements and recommendations for future projects.

Community Participation; Hans Hedemalm, SweRoad

Mr Hedemalm started by introducing the 3 keys to poverty reduction and the overall goals in Lao PDR.to be implemented through the Strategic Vision 2020 and the National Growth and Poverty Eradication Strategy (NGPES). He then outlined the concept of Basic Access and the process for providing this, though planning, implementation and maintenance by the Village Maintenance Committees. He explained that the maintenance initiative must be supported by some subsidy and cost sharing, on a sliding scale according to road classification. To achieve this there must be some sense of ownership by the communities. He concluded with several suggestions as to how to successfully implement the VMC approach.

2.2.4 Experience from other Projects and Research Worldwide

Surfacing Low Volume Roads; T Greening TRL Zimbabwe

Mr Greening started by showing many examples of rural roads in Africa. He commented on the constraints of using gravel as a surface material and the traditional criteria for applying bituminous surfacing. He gave examples from DfID research in southern Africa where marginal materials had performed better than predicted. As a result of this research they were able to review the designs and specifications, with a resulting reduction is costs and a lower threshold for applying bituminous surfaces. He went on to explain a holistic approach for sealed roads and the technical aspects of design construction and maintenance. He then introduced the SADC Guidelines for low volume sealed roads and highlighted the issues about sustainability. He concluded by stressing the need for knowledge sharing and the fact that although the environment in Africa is different to Lao PDR, there are lessons to be learned from both sides on the problems encountered and their solutions.

Developing Appropriate Rural Road Standards for Vietnam; Dr Tam ITST

Dr Tam started his presentation by describing the Vietnam road network and the problems being faced with the two common pavement types, gravel and penetration macadam. Other issues included limited resources for construction and maintenance, adverse weather conditions, poor construction materials and poor maintenance. He then explained the Mekong Delta Bridge and existing rural road standards and the required initiatives for rural road standards. He continued by describing the rural road surfacing research initiative and the trials strategy supported by the World Bank and DfID under the RT2 project and concluded his presentation with a description of the trials strategy and funding arrangements.

2.3 Discussions

The presentations were grouped into four sessions, as detailed above. At the end of each session, time was allowed for discussion and comments on the presentations. The key issues raised and comments are detailed below. Because of the nature of the discussion, the summary is grouped by topic, not necessarily in the order in which they were raised.

2.3.1 Introduction to SEACAP 17 – Lao PDR

Pavement Design

- A question was raised about the unit prices of the SEACAP trial pavements. An explanation was given about the process of designing the trial pavements and including them in the contract packages being prepared by the NEC consultant. Higher cost and low cost solutions would be balanced to ensure that the overall cost of the packages would not have a significant increase.

- Peter O'Neill added that we should look at the whole life cost of a road and that a sustainable solution will avoid high maintenance and rehabilitation costs in the future.
- At present the provinces use the same surface for all pavement problems, which does not work especially in the case of overloading

Overloading

- SweRoad have been addressing the issues of overloading and their approach has been to be prepared to repair and maintain as necessary.
- The SEACAP project will include monitoring of overloaded vehicles and to make recommendations.
- In Cambodia, one trial section was destroyed by overloaded trucks from an illegal quarry transporting wet sand during the rain season. Their approach was to identify high risk roads and design accordingly. In developing low cost pavements we must identify low risk roads. We must also look at the levels of maintenance and where the resources will come from. In some cases it is necessary to design for no maintenance. One solution in Cambodia is to have physical barriers to restrict vehicles.
- The local participants were then asked if they experienced problems in the project area. In response, they advised that logging trucks are the main problems but these use the main highways and not the access roads.
- An additional comment was that overloading is an enforcement problem, not a technical one, which needs support and the involvement of the communities

Expectations

- Mr Somnuk asked the participants what were their expectations from the research and from this workshop.
- The key responses were that the workshop gave an opportunity to see the importance of using local resources to solve rural access problems.

Community Participation

- A contribution was made from the SEACAP experience in Vietnam regarding the local views on road construction. The communities still see roads as external roads not their own. If they build their own roads, they give instructions to the contractors and take more interest.

- P O'Neill added that it is difficult to get people involved when a road just passes through a village and is better if a road goes directly to one village. He asked for contributions on what might work to get a better sense of ownership.
- Experience from pilot projects in Louang Namtha showed that roads built by the communities were maintained better. This was supported by the remark that where roads are built by communities, there is a sense of involvement.
- Government enforcement of load restrictions and increased standards are not the solution. In addition they need community participation. It was added that the ownership and community participation strategies need to achieve the same success as the community built roads.

2.3.2 Experiences from the Region

- Mr Petts asked for contributions on the experience of gravel roads in Lao PDR.
- In Bokeo, contracors were used for the construction but they have transferred knowledge to the local communities along the road for maintenance. The province provided the hand tools for maintenance. They have monitored the road and found positive results. Local people are happy to get new roads and even though they do not build themselves, they see the benefits. The province has allocated one maintenance engineer to lead the operation.
- In Oudomxai they find that the same vehicles use the access roads as use the national roads, however the access road standard is much lower. As a result of the heavy loading the access roads are damaged. They encourage villagers to maintain roads using local material once a year during the dry season.
- Oudomxai have received excellent knowledge from the experiences in Vietnam, particularly the hand packed stone and need the expertise from these countries. They would be interested in a DfID project in their province.
- Louang Namtha province has five districts, three of which are mountainous. They have a limited budget and have investigated methods of gravel road maintenance. The main problems include the effects of overloading and drainage. To solve the problem they involve the local communities. Contractors place stockpiles of gravel for use by the communities. The communities do bush clearing and ditch cleaning, however there is no budget for this work. They hope the governemtn will provde a budget an technical assistance.
- In Louang Prabang province the terrain is the main challenge, particularly with erosion. They want good quality long life roads. Proposals to change gravel roads to paved roads

under the Wold Bank project were not successful. Crushed rock is expensive and underground water is a problem. Maintenance by the communities is not very successful as it is seen to be the government's responsibility.

- In discussion about materials in the region, it was found that there is no real selection process, which has an impact on the quality and life of the pavement.
- A general question was raised about the split between trials in rural and urban areas and on unit costs of the trials. The view was that technically it does not matter whether roads are urban or rural. A location 20km from a town is convenient for monitoring purposes. Unit costs are very variable and depend on the environment. There is a framework developed for determining unit rates based on various factors relating to the road environment.

2.3.3 Experiences of Rural Access in Lao PDR

Community Participation

- It is important to identify the labour force. To ensure a good availability of labour, projects should make a plan for maintenance during the non-farming season. There should be a good supply during the dry season.
- Because of labour shortage, one province mobilised labour from Vientiane. In mobilising labour, it is important to look at the distances involved. We also have to look at the overall benefits to the project or the community.
- In Oudomxai, there is sometimes a problem with labour supply and they have to use equipment. They feel that the villages are the beneficiaries of the roads and want the communities to be the owners, not only to use their labour to build the roads.
- The Village Maintenance Committees (VMC) were created in 2001. Originally there were 228 VMCs, which has now increased to 338 nationwide and work is still ongoing to include more communities. Seven provinces are supported by the Road Maintenance Fund (RMF) at about 129 million Kip per province. There are not enough funds in the RMF for all provinces, which could be helped with support from DfID. A suggestion was made that funds be raised from a fuel surcharge and from toll booths.
- In Cambodia, VMCs were not successful as too little money was raised through road tolls.

Specifications

- In response to a question about plasticity index (PI), Mr Roy explained that it must be controlled. They do not want to have the risk of failure. He went on to explain the specification for different materials.

- Tony Greening added that the PI itself is not a good indicator and that the Placticity Product is more realistic.

2.3.4 Experience from other Projects and Research Worldwide

General

- It appears that all the ideas come from outside the country. Sustainability needs political support for the policies. It was added that the politicians control the funding and they need to be on our side and understand the issues.

Quality Control and Specifications

- The costs of maintenance are high. Construction and maintenance costs are linked. Good quality control during construction can reduce the costs of maintenance.
- Mr Greening responded with the comment that often failures have nothing to do with specifications but with poor supervision. Specifications are often from outside the country and are not appropriate for local materials. However, we do not throw out the specification, only make sure it is appropriate for the local conditions. In Vietnam, recommendations on the specifications for the trial pavements will be made based on the construction works. This is expected in mid 2005.
- The TRL presentation only talked about successes. Sometimes there are failures and there is a risk from using that design. No-one wants a road to fail and we must manage the risks by knowing the materials being used.
- The options considered for surfacing are single or double seal. Single seal offers a higher risk of failures whereas double seal is expensive. There are other surface options, such as the graded aggregate seal.
- Width standards can vary. On access roads there is no need for a wide pavement but oncoming traffic must be able to pass. One experience in Africa was to use a 6 metre base and a 3 metre surface, thus providing a good running surface but allowing oncoming traffic to pass.
- In Vietnam a World Bank project had a gravel road standard of 3.5 metres. A local village wanted to extend the road using its own funds and built a 1.5 metre concrete road for the same cost as the WB gravel road and still provide adequate access for the types of vehicle on the road. The reasoning was that the village wanted a more substantial road with a lower maintenance burden

2.4 Workshop Close

The workshop was brought to a close by Mr Somnuk, who summed up the proceedings of the two days and invited Mr Viengsavath to make his closing remarks.

Mr Viengsavath thanked the participants for attending the workshop and for participating in interesting presentations and useful discussions. He was pleased that the participants had both contributed to the workshop and learned about the possibilities for solving the rural access problems in Lao PDR. With these comments he declared the workshop closed.

3 CONCLUSION

3.1 Expectations and Outcome

The Knowledge Exchange workshop was held with two distinct purposes. First to introduce SEACAP and the SEACAP 17 project to the staff and consultants of MCTPC. The second and main objective was to share experiences from projects within Laos PDR and from the SE Asia region and worldwide.

The workshop included participants from MCTPC in Vientiane, including technical staff from the Local Roads Division, and from 6 provinces as well as expatriate staff working on MCTPC projects. Most of these participants had little or no knowledge of SEACAP or the SEACAP 17 project and what they have to offer to Lao PDR. During and after the workshop, there were many requests that other provinces be included in the SEACAP programme.

Throughout the workshop, both in the presentations and discussion, participants heard the experiences from other countries, many of which are appropriate to the Lao PDR environment. From the questions raised during the discussion sessions, it was clear that there is a keen interest within MCTPC to learn from these experiences and be able to apply this knowledge to address their own problems.

During the discussion sessions, many MCTPC participants contributed their experiences and related their problems to the workshop. This gave the international delegates knowledge of the issues relating to rural access in Lao PDR.

The overall consensus was that the workshop had been a success for both the local and international participants. It provided the opportunity to learn from each other about the problems with providing rural access and the potential solutions available.

APPENDICES

APPENDIX 1

Agenda

Ministry of Communications, Transport, Post and Construction

SEACAP 17 Knowledge Exchange Workshop
Vientiane 15-16 December 2004

AGENDA

15 December

9.00	Registration		
9.30	Opening Address	Viengsavath Siphandone	MCTPC
9.50	Welcoming Address	Mr P. O'Neill	DfID
10.10	Coffee Break		
10.30	**Introduction to SEACAP 17 – Lao PDR**		
	Introduction to SEACAP	P Caine	Halcrow
	Project Overview	M James	Roughton
	Pavement Engineering	SD Gillett	Roughton
11.30	Discussion		
12.15	Lunch		
13.45	**Experiences from the Region**		
	Surfacing Research in South East Asia	R Petts	Intech Associates
	Natural Gravels in Vietnam	Dr J Cook	TRL
	Low Volume Rural Road Pavements		
14.45	Tea Break		
15.15	Monitoring of Low Cost Surfacing Pavement trials in Cambodia	H Kackada	Intech Associates
15.45	Discussion		
16.30	Close		

16 December

9.00	**Experiences of Rural Access in Lao PDR**		
	Experience of Rural Access in Lao PDR	Ounheuane Siriamphone	MCTPC
	Access road component of the ADB 8 Project	Emilian Roy	Buarapha
	Community Participation	H Hedemalm	SweRoad AB
10.00	Discussion		
10.30	Coffee Break		
11.00	**Experience from other Projects and Research Worldwide**		
	Issues arising from SADCC guidelines on low cost surfaces	T Greening	TRL
	Required Initiatives on Rural Road Standards	Dr Doan Min Tam	ITST Vietnam
12.00	Discussion		
12.30	Summing Up		
	Closing Speech	Chairman	MCTPC
	Lunch		

Appendix 2

List of Participants

No.	Name and Surname	Organisation
1	Mr Viengsavathe Siphadone	Dor/MCTPC
2	Mr Emilien Roy	Burapha
3	Mr Bouachanh	Dor/MCTPC
4	Mr Perter O'Neill	DfFID
5	Mr Paul Caine	Halcrow
6	Mr Narendra Singru	Halcrow
7	Mr Robert Petts	Intech -TRL
8	Mr Tony Greening	T R L
9	Mr Jasper Cook	Intech -TRL
10	Mr Heng Kackada	Intech -Cambodia
11	Mr Doan Minh Tam	ITST Vietnam
12	Mr Le Due Tho	Intech-TRL
13	Mr Hongla	DCTPC/ Luang Namtha
14	Mr Sengmany	DCTPC/ Phongsali
15	Mr Thongsavanh	DD
16	Miss Vilaysone	DD
17	Mr Lothoun	DCTPC/Bokeo
18	Mr Khamphath	DCTPC/Bokeo
19	Mr Houmphan	Dor/ESD
20	Mr Soulinet	Dor/ PTD
21	Mr Vichit	Dor/LRD
22	Mr Vongprachanh	R 3/NEC P
23	Miss Vienkeo	Halcrow
24	Mr Phengnilanh	DCTPC/Sayabouli
25	Mr Bounbor	DCTPC/Sayabouli
26	Mr Asween	DCTPC/Louang prabang
27	Mr Khamphou	DoR/PAD
28	Mr Kayakeo	DCPTC/Oudomsay
29	Mr Maysy	R&D Committee
30	Mr Vongdouane	Dor/LRD
31	Mr Phommouang	DCTPC/Luang namtha
32	Mr Somnuk Mektakul	Dor/LRD
33	Mr Nolasack	Dor/LRD
34	Mr Inthapada	Dor/LRD
35	Mr Ounhuane	Dor/LRD
36	Mr Bounlang	DCTPC/Louang prabang
37	Mr Phan Phoutavong	Dor/MCTPC
38	Mr Nakhonkham	Dor/LRD
39	Mr Hans Hedemalm	LRD/Sweroad
40	Mr Mike James	Roughton
41	Mr Saysomephone	Dor/LRD
42	Mr Souksakhone	Dor/LRD
43	Mr Simon Gillett	Roughton
44	Mr Sune Olsson	LRD/Sweroad
45	Miss Pingkeo	Dor/LRD
46	Mr Keovilay	DoR/RAD
47	Mr Lars Jamten	RAD/TA
48	Mr Daochinda	DoR/PMD
49	Mr Masami Fukuda	Oriental Consultants
50	Mr Souvany	DoR/PD
51	Mr Khamphet	LRD
52	Mr Alan Cutler	Roughton

Appendix 10

Paper Presented at IFG Meeting Arusha

Paper Presented by
Somnuk Mektakul, Deputy Director Local Road Division, MCTPC
at the 5th IFG Meeting, Arusha, Tanzania, March 2005

Executive Summary

The Lao People's Democratic Republic is in the centre of the Mekong region of South East Asia, bordered by Thailand, Vietnam, Southern China, Cambodia and Myanmar. Lao PDR has a population of around 5.5 million, approximately 23 persons per square kilometre, the lowest population density in the region. It has significant natural resources like forestry, minerals and hydroelectric power. Agriculture remains the major sector of the economy.

Road is the dominant mode of transportation in Lao PDR. About 75 percent of freight and 93 percent of all passenger traffic is carried by road and the development of an efficient transport system is of paramount importance for regional integration and socio-economic development of the country. The Lao PDR road network is estimated to have a length of 31,291 km (April, 2004), of which 14.5 percent is paved. About 40 percent of the total road network is in excellent to good condition, although for National roads this figure rises to 73 percent. Access constraints remain significant, with 26 percent of National roads and 34 percent of Provincial roads experiencing closures over more than 3 months per year The road network is lightly travelled; only 12 percent of National roads carry over 1000 vehicles/day. Provincial and rural roads generally carry traffic below 50 vehicles/day.

The road network has been continually developed since 1975; however, the main focus was initially on road construction. Since the late 1980's projects have increasing focussed on maintenance, although in most cases this has not produced sustainable results. Recent projects with maintenance components include ADB2, World Bank 3rd Highway Project and Road Maintenance Project (RMP1) and the Lao Swedish Road Sector Project 2. Future projects focussing on sustainable maintenance include the Road Maintenance Project 2 and LSRSP 3.

Given budget constraints, the Government had difficulty generating sufficient additional funding for road maintenance or reallocating funding from other sources. Accordingly, the Government established the Road Maintenance Fund under the RMP1 project. The RMF became operational in 2002. The Provincial Road Maintenance Management System (PRoMMS) was also developed under RMP 1. It is used, among others, to prepare the Annual Routine and Periodic Maintenance Plan for the District and Rural Roads (DRR) and its bridges. The total DRR maintenance and rehabilitation needs for the year 2004-2005 is approximately US$2.56 million.

Community participation in road maintenance was developed under LSRSP II to involve local communities in the process of planning and implementing investment and maintenance works on district and community roads, as well as on other types of access. The reason for involving rural communities is that public funds are insufficient to create and sustain the basic access that is needed in order to help provide basic access to rural people. The result was a plan for community participation integrating PRTP, village-based maintenance and improvement works for rural access, later named the Community Road Model (CRM). The CRM is designed as a sustainable management model for the further development of basic access in rural areas of Lao PDR. Its in-built cost-sharing principles result in a reduced cost for the government with the aim to make the system financially sustainable.

SEACAP is a rural transport research, dissemination and uptake programme with the objective of supporting the uptake of low cost, sustainable solutions for rural access. The SEACAP Project aims to identify cost-effective community orientated approaches for improving all year access to remote rural areas through a low-cost and local resource based improvement of roads in Lao PDR. The project is being implemented through the ADB funded Northern Economic Corridor Project in northern Lao PDR.

Appendix 11

Activity Schedule

Module 1 Activity Schedule