Highway Engineering Report

Project Number: 47086
March 2014

MYA: Maubin-Phyapon Road Rehabilitation Project

Prepared by M. Zachara, Highway Engineer/Consultant for the Asian Development Bank.

CURRENCY EQUIVALENTS
(as of 15 March 2014)

Currency unit	–	Kyat (K)
K1.00	=	$0.010
$1.00	=	K966.46

ABBREVIATIONS

ADB	–	Asian Development Bank
AADT	–	annual average daily traffic
AASHTO	–	American Association of State Highway and Transportation Officials
BOQ	–	bill of quantities
CBR		California bearing ratio
cm	–	centimeter
CSC	–	construction supervision consultant
DCP	–	dynamic core penetrometer
ESAL	–	equivalent single axle load
JICA	–	Japan International Cooperation Agency
km	–	kilometer
m	–	meter
m^2	–	square meter
m^3	–	cubic meter
MDD	–	maximum dry density
mm	–	millimeter
MPT		Ministry of Post and Telecommunications
MOC	–	Ministry of Construction
OFC	–	optical fiber cable
OMC	–	optimum moisture content
PI	–	plasticity index
PW	–	Public Works

NOTES

In this report, "$" refers to US dollars unless otherwise stated.

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EXECUTIVE SUMMARY

INTRODUCTION

1. The proposed road project between Maubin and Phyapon will include the reconstruction and widening the 54.45 kilometer (km) length of road (including 2 sections through urban areas) and also bridge and drainage structure improvements. Although seemingly straight forward, the road works are complicated by the presence of poor ground conditions, standing water throughout most of the year, but especially during the wet season, the presence of a major underground communication cable in the road formation and the lack of readily available and appropriate construction material. The need to widen the road and build over soft ground, presently used for rice growing will also mean that a part of the widened road embankment is likely to settle, even though every effort will be made to minimize this by programming the construction works so that traffic uses the widened portions and accelerates the settlement before the final pavement layers are constructed. Due to the possibility of settlement, the adopted surfacing is asphalt concrete as preferred by the Ministry of Construction (MOC).

A. Road Construction

2. The presence of the underground cable has required the road to be moved laterally by 3.5 meters (m) and, thus, constructing the widened embankment over a soft and wet ground for at least the first 25 km of the road's length and for lesser widths along most of the remaining length. The proposed road formation width for the rural road sections is 11.4 m, of which 10.2 m will be surfaced, including 1.8 m for each shoulder. The urban sections will be a 7 m paved surface with gravel shoulders[1]of varying width.

3. The road height will be raised by an average of 35 centimeters (cm) to ensure that the road has additional clearance over flood water and to allow the reconstruction of the road embankment. Because of the short nature of the study and limited survey work, the construction supervision consultant will establish the final road levels after a detailed survey is completed in the first months of the contract.

4. As a horizontal shift in the road alignment is not possible at the more significant bridges and the road will need to return to the existing centerline at these structures, it will be necessary to relocate the communication cable on the approach and departure of bridges and 2 cable road crossing locations. The Ministry of Post and Telecommunication were consulted on this and have agreed, in principle, to the relocation. In addition to these relocations, it will also be necessary to relocate electricity lines (including an 11 km section) and a few telecommunication poles along the road.

5. The lack of suitable material in the project area, even for common fill, means that most of the required construction materials have to be imported. To lessen the cost of the road works, maximum use will be made of local construction materials by improving their properties by using lime and mixing them with other materials. The contractors will, therefore, have to have suitable equipment that includes an in-situ stabilization equipment and/or material mixing plant capable of handling and blending 4 different materials including the modification/stabilizing agent. The contractors will also, of course, need to develop sites for the blending/mixing operation and for stockpiling construction materials, prior to them being placed on the road.

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[1] The new road surface will be at or within 100 millimeters of the existing paved road surface. The gravel is, therefore, used to make sure that there is no drop off at the edge of the paved surface. It is understood that the municipal authorizes will construct concrete shoulders or pathways adjacent to the proposed concrete pavement at a later date.

B. Bridge Works

6. The structural elements of the project will include the possible widening of 2 simple short span slab bridges,[2] the upgrading of the single lane 3-span Oo Yin Chaung bridge, the replacement of the Kyee Chaung bridge (13 m), and the possible widening and/or replacement of a 16 m bridge in Kyaiklat Township over Pagoda creek.[3] The upgrading works for the Oo Yin Chaung bridge will include the widening of the existing abutments and the construction of a 2 lane superstructure. Structural works at other locations will include the raising of wing, head, and abutment return walls, and the lengthening of many of these. It will also be necessary to lengthen 3 pipe culverts and construct headwalls, and possibly carry out other corrective tasks which could not be assessed as the culverts were underwater at the time of writing this report.

C. Pavements

7. Two types of pavements are proposed, namely flexible pavements for the rural road sections and rigid pavements for the two urban sections, in Kyaiklat and Phyapon respectively. The designs were based on TRL Road Note 31 for the flexible pavement and on the American Association of State Highway and Transportation Officials[4] for the rigid pavements. The adopted design traffic load was 7 million equivalent single axle load (ESAL) over a 20 year design life. This was based on current traffic levels, and the assumptions that 40% of trucks are unloaded and that loaded trucks are 15% overloaded. Growth in ESAL over the project's design life has been assumed, based on traffic studies that were part of this technical assistance's scope, to be 13.2% per annum.

8. The designs were based on past soils studies and a short program of testing that was carried out by the MOC Road Research Laboratory. The August/September 2013 investigations and testing showed that subgrade conditions were poor with soaked California bearing ratio (CBR) values as low as 1% but typically 2% to 3%. Moisture conditions in the subgrade were 2 to 2.5 time the optimum moisture content with many locations recording a moisture content greater than 30%, which is greater than would occur after 4 days of soaking and is more likely to be represented by samples soaked for 7days, where local soil samples recorded CBR values of 1%. The high moisture content environment is, it is believed, the result of poor pavement structure drainage in the existing pavements which are constructed as "boxed" pavement structures which are known to retain water and lead to saturated road conditions.

9. Given these conditions it is proposed that an improved fill and subgrade layer, both with CBR values of at least 5% underlie the pavement structure itself. The proposed pavement structure will also include improved pavement structure drainage and surfaced shoulders that are designed to stop water wetting up the pavement under the traffic lanes. This should ensure that embankment moisture conditions are significantly improved.

10. While a number of flexible pavement types were considered including the use of cement stabilized layers and an asphalt concrete surfacing the proposed pavement and upper embankment levels include a lime modified improved fill, a sand/soil blended

[2] These small slab bridges will not need to be widened if Myanmar Post and Telecommunication confirm their unofficial advice that they would be able to relocated the optical fiber cable at the 2 bridges.

[3] PW were in the process of carrying out investigations/design of the Kyaiklat township bridge at the time of writing this report.

[4] The American Association of State Highway and Transportation Officials (AASHTO) is a standards setting body which publishes specifications, test protocols and guidelines which are used in highway design and construction throughout the United States. Despite its name, the association represents not only highways but air, rail, water, and public transportation as well.

subgrade (both with a minimum CBR of 5%), a sand/soil/river gravel subbase, a dense graded crushed rock base and an asphalt concrete surface. Total cost of the project road with asphalt concrete surfacing (including concrete pavement in the urban sections) and the upgrading and/or replacement of 3 bridges is $ 54.1 million.

D. Road Maintenance

11. The proposed project road includes features that should lead to good ride quality for close to 15 years with rehabilitation required after 20 years, possibly even 25 years. This will, however, only be possible if there is a change in the road management philosophy and approach in Myanmar, with a move away from the repair and reconstruction mentality to one of maintenance, preservation and rehabilitation. The focus should be on extending pavement life and delaying the need for major works.

12. The present strategy is a high cost, low road performance strategy that cannot be continued if the Government of Myanmar is to improve the condition of the country's road network. No country can afford to achieve the required improvements, using the current strategy, with all leading road authorities working to extend the life and performance of roads and delaying the need for all major work tasks, including periodic maintenance and reconstruction, for as long as possible. Significant funds have been directed internationally to research projects that would deliver improved road performance and this has resulted in the adoption of new materials, techniques and new road management strategies, such as the preventive maintenance strategies that have extended pavement lives by 5 to 10 years beyond their design lives.

13. For the project road, this will mean resurfacing (sprayed seal) the road in approximately 6 years and again in 12 years, after construction, with funds also allocated for annual routine maintenance and some minor repairs throughout the pavement's life. The focus of the maintenance should be prevention first, with action being taken within days and weeks of defect identification rather than months and years. This change in thinking will possibly require a change in the way maintenance work needs are identified and funded with MOC/PW District Offices having the authority and the ability to take action when needed.

I. INTRODUCTION

A. General

1. This report sets out the findings and engineering design details of the study into the rehabilitation of the road between Maubin and Phyapon. The proposed works, namely the reconstruction and widening the 54.45 kilometer (km) length of road (including 2 sections through urban areas), although seemingly straight forward, are made more complex because of the poor ground conditions, the presence of water throughout most of the year, but especially during the wet season, the presence of a major underground communication cable in the road formation, and the lack of readily available and appropriate construction material.

2. The presence of the underground cable has required the road to be moved by an average of 3 meters (m), which means constructing and widened the embankment over a soft and wet ground for at least the first 29 km of the road's length. This could cause a delay in construction as ground conditions will need to dry out before the embankment foundations can be prepared to accept the widened embankment. Land owners will need to be asked not to flood the field where the widening is to take place in the 3 months preceding the foundation preparation.

3. The structural elements of the project will include the possible widening of 2 simple short span slab bridges[5], the upgrading of the single lane 3 span Oo Yin Chaung bridge, the replacement of the Kyee Chaung bridge (13 m) and the widening and/or replacement of a 16 m bridge in Kyaiklat Township over Pagoda creek[6]. The upgrading works for the Oo Yin Chaung Bridge will include the widening of the existing abutments and the construction of a 2 lane superstructure.

4. Other structural works include the raising of wing, head, and abutment return walls, and the lengthening of many of these. It will also be necessary to lengthen 3 pipe culverts and construct headwalls, and possibly carry out other corrective tasks which could not be assessed as the culverts were underwater at the time of writing this report.

5. The lack of suitable material, even for common fill, means that most of the required construction materials have to be imported, some from long distances. To lessen the cost of the road works, maximum use is to be made of local materials. Materials to be used include:

- (i) silty sand from the river – road fill;
- (ii) lime stabilized soil and silty sand – improved fill (California bearing ratio [CBR] of 5%);
- (iii) blended soil/silty sand – subgrade;
- (iv) shingle/sand/soil blend or a stabilized sand soil blend – subbase;
- (v) dense graded crushed rock (blend of crushed dust, 6 millimeter (mm) plus and 10 mm to 20 mm crushed rock fractions) – base; and
- (vi) crushed rock aggregate – asphalt concrete surfacing.

B. Background

6. The objective of the project is to develop proposals, designs, and bidding documents for the rehabilitation of the Maubin to Phyapon Road, which is a priority link in the

[5] These small slab bridges will not need to be widened if Myanmar Post and Telecommunication confirm their unofficial advice that they would be able to relocated the optical fiber cable at the 2 bridges.
[6] PW were in the process of carrying out investigations/design of the Kyaiklat township bridge at the time of writing this report.

Government's key infrastructure development agenda as it will improve connectivity to the rich agricultural Ayeyarwaddy Delta, and, in so doing, support inclusive economic growth. The 55 km section of road is to be improved to an appropriate 2 lane standard with appropriate width shoulders, suitable for all standard highway traffic.

7. The study document covers engineering, safety, economic, social, gender, and environmental aspects and engineering studies, namely, condition assessment; work needs assessments, road standards, pavement design, cost estimates, bidding documents and an implementation plan. The related economic study, documented in a separate report, has conducted traffic surveys and assessed the economic feasibility of the project. The accompanying financial analysis also did an assessment of the financial management systems and capabilities of the implementing agency (Public Works [PW]).

8. The project also includes social impacts, resettlement and environmental components, each of which have prepared reports, namely, an initial environmental examination, poverty and social assessment, resettlement plans, and a stakeholder communication strategy. These have included surveys and consultation with communities along the road. These reports are included in separate volumes.

9. The proposed road project is part of the Ministry of Construction (MOC) program and will be implemented by PW.

C. Summary of Key Project Issues

10. The issues and observations that will impact the engineering details and implementation arrangements for the road project are detailed below. Most relate to the site conditions, availability of suitable materials, capability of local suppliers to supply on time, relocation of road side services, and sprayed sealing.

11. The issues that will and/or may impact on the implementation of the project include:

(i) Construction material (embankment and subbase materials) availability. The construction solutions that have been identified will require the processing of a large quantity of materials. The process will include blending of materials and, in some instances, adding cement or lime to further improve the material properties. It will also include crushing of existing pavement materials salvaged from the existing road. All these tasks will require an experienced contractor and require the development of facilities for offloading materials delivered by water and sites for the storage and processing (blending) of materials. The study has not been able to establish the capacity of the current suppliers to supply the required materials at the rate required. The materials initially required are silty sands that will be won from the river;

(ii) Ground conditions of the area that will form the foundation for any road widening and those parts of the existing embankment not directly under the existing traffic lanes, will, although compacted to the extent possible, settle at a different rate to the part of the embankment under the traffic lanes. Differential settlement is, therefore, likely. This is especially so in those areas where it may not be possible to dry out (or even to remove the water completely) before the widened embankment is constructed;

(iii) Transport of higher quality pavement materials. This will be done by river transport and by road. Reasonably priced (for Myanmar) crushed rock is available from the Mandalay region. Transport from this area is, however, limited after the end of February, except in small quantities, because of low levels in the Ayeyarwaddy River. While alternate sources can be sourced from Moulmyaing in Mon State (delivered by sea) the cost is reported to be 20 to 30% higher. Other sources located to the west of the project road and delivered by road from Myaung Mya are weathered rock of subbase quality (high Los Angeles abrasion) only. As crushed rock will only be required for the base and surfacing layers, it would not normally be required for at least 9 to 12 months after works commencement, although this will depend on how the contractor chooses to do the construction.[7] The effect of possible delays could be mitigated by bringing in materials over a longer period and stock piling after blending (areas would need to be prepared for both the blending and stock piling) close to the road so that the material ready when needed;

(iv) Supply of crushed rock. Most crushing operations are reportedly small and there is, therefore, likely to be a variation in quality and the rate of production of required sizes (limited, as is the supply), given the competition from other projects. Only 1 large crusher (350 tons/hour) has been identified to-date (in Mon State). The above situation is complicated due the availability of explosives, which are controlled by the Ministry of Home Affairs and the Ministry of Defense. Requests for explosives need to be made 1 year in advance, although some contractors hold reserves that are stored at the Ministry of Defense installations.[8] Given the above, pavement options that minimize the use of crushed materials have been explored;

(v) Underground communications cable location is not well defined. Distance from the road centerline varies, as does the side on which it is located. The positions recorded by PW district offices and shown on the contract drawings will be indicative only. Although the road will be moved to one side by 1 m to 4 m, there are 3 locations where the cable switches from east to west of the road centerline and vice versa. There will, therefore, be lengths of road where the contractor will have to work around the cable. The contract documents will require the contractor to identify the exact location of the cable before any excavations are started and require that Myanmar Post and Telecommunications (MPT) people be on site when road works are being carried out where the cable crosses the road;

(vi) Relocating of communication fiber cable at medium to large bridges (8 bridges and at 3 of the points where the cable crosses the road). MPT has inspected the nominated locations and are finalizing the estimates. MPT will seek funds from the Government to do the necessary work. MOC is to confirm the locations, and the timing for moving the cable before MPT start this work. The work would need to be completed before the end of December 2014;

(vii) Contractors will have to have equipment for mixing and/or blending embankment and pavement materials. Some of the work can be done with stabilizing equipment and some will require a mixing plant. The contract documents list this equipment.

(viii) Asphalt Concrete equipment (batch plant, paver and rollers) will need to be of a quality that will produce the required seal quality. The equipment should ideally come with a certificate of recent inspection and calibration, although this is not always possible. The equipment will be checked and calibrated on site and tests seals completed before being allowed on the road;

(ix) Relocation of other service such as power lines and some above ground telecommunication cables will be needed. A list of locations will be included on the drawings for action by PW.

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[7] Complete the road to subbase level for all or most of the contracted road section and then start of the base and complete the seal or he could choose to complete section of say 5 to 10 kilometers, including the base layer and seal.

[8] Explosives are delivered to the quarry site, escorted by the army or police, whose costs are covered by the quarry operator. A tax (a form of royalty) is also paid for the material carried away from the quarry sites.

II. ROAD SECTOR IN MYANMAR

A. Introduction

12. The road sector is in many respects a description of the PW as they, until recently were responsible for all road construction and maintenance. While this continues to be the case for all public roads some private sector consultants have been carrying out investigations and design for private sector developments. Those consultants include some standalone consultancies and consulting firms that are part of a large multi-faceted development groups. The same applies to construction with most of the contracting companies being a part of a larger development group.

13. Although independent of the government, when involved in private sector work, both the contractors and consultants follow methods and procedures that are essentially those of PW. Estimating procedures, specifications, standard drawings and the solutions proposed for road works are essentially those of the PW. The introduction of new methods as evident in the building industry, have yet to be seen in road works.

B. Road Management

1. General

14. MOC is responsible for the construction and maintenance of approximately 39,000 km of national, regional, and state roads. It is also responsible for airport development and maintenance, for government building, and housing development and maintenance.

2. Ministry of Construction Structure

15. The MOC is headed by a Union Minister and supported a Deputy Minister who, with their staff oversee the operations of the 2 departments as follows:

- (i) Human Settlement and Housing Development Department, headed by a Director General; and
- (ii) PW, headed by a Managing Director.

a. Public Works (PW)

i. PW Structure

16. PW is an enterprise that is managed by a management board consisting of the Managing Director and 4 deputy Managing Directors. There are 8 Chief Engineers and 13 deputy chief engineers at the head office in Nay Pyi Taw. There are also 4 supporting divisions headed by General Managers, who are non-technical senior administrators (please refer to Appendix E).

17. There are 17 Regional and State offices headed by a superintending engineer and 66 District Offices headed by an Executive Engineer.

18. While the district offices are shown to report to the Repair and Maintenance Department in the organization chart, they also report to the Works Department as each district office also carries out capital works.

ii. PW Responsibility

19. PW is responsible for the development and maintenance of road, bridges, airports

and related building infrastructure as well as building and related services for government administration, education, health, transportation and industry.

iii. Public Works Operations in the Project Area

20. The project road is located in 2 Districts, namely Maubin and Phyapon. Thirteen kilometers of the road are in Maubin District and 42 kilometers in Phyapon District. PW have offices in both districts.

21. There is also a Regional Office in Pathein (Ayeyarwaddy Region), located well to the west of project road and 2 special bridge construction units based in the region.

22. The two PW District Offices are presently responsible for all works on the project road and will of course take on the same responsibility after construction and the defect liability period.

23. The district offices are responsible for the development of road rehabilitation and maintenance proposals including cost estimates and also for implementing the resulting approved works program. The funds for approved works are transferred directly into the District Office bank by PW in Nay Pyi Taw.

C. National Road Network

a. National Road Network Characteristics

i. Road Lengths

24. The total formal road network length has been growing an average annual rate of approximately 6% since 2004, as indicated in Table II-1 below. The network managed by the MOC has grown by an average of approximately 3.5% since 2004.

25. As will be noted the length of paved road network is around 22% of the total road network and 45% for the PW managed road network.

26. Table II.2 summarizes the road characteristics by road class and surface type as at March 2012. At that time, 45% of the MOC administered road network was paved. The percentage of paved roads in Ayeyarwaddy region is 42% which is slightly below the PW managed network average.

27. The paved road percentage for the Union (National) Highway network was 63% while that for the regional and state roads was only 28%.

Table II-1: Road Network Length

	Responsibility of MOC (km)			Total Road Network		
Year	Total Length	Paved Length	% Paved	Total Length	Paved Length	% Paved
2004	29,497	14,126	47.9	90,713	22,153	24.4
2005	29,825	14,356	48.1	92,859	22,830	24.6
2006	30,433	14,956	49.1	104,058	23,955	23.0
2007	30,711	15,213	49.5	111,737	24,670	22.1
2008	30,902	15,387	49.8	125,355	25,553	20.4
2009	32,070	15,583	48.6	127,942	26,333	20.6
2010	34,178	16,550	48.4	136,749	28,569	20.9
2011	37,784	17,260	45.7	142,395	30,879	21.7

km = kilometer, MOC = Ministry of Construction.
Source: PW.

28. The percentage of paved roads, as a percentage of the total road network has decreased between 2005 and 2011 from 24.6% to 21.7%, mostly in the road network managed by organizations other than MOC, except between 2010 and 2011 when there also appears to be a decrease in the MOC managed roads. The reason for this is not clear.

Table II-2: Road Network Length, March 2012 (km)

Road Category	Concrete	Bitumen	Gravel	Metalled	Earth	Track	Total
Union Highway	611.7	11,733.0	2,440.8	2,700.3	1,973.5	44.1	19,503.2
Regional and State Roads	49.7	5,451.8	3,299.6	2,941.4	6,497.1	1,340.0	19,579.5
MOC Total	661.4	17,184.8	5,740.3	5,641.7	8,470.6	1,284.1	39,082.7
Ayeyarwaddy Region	17.5	1,057.6	335.1	559.8	577.1	0.0	2,547.2

km = kilometer, MOC = Ministry of Construction.
Source: PW.

ii. Road Condition

29. Appendix D includes a condition assessment carried out by PW in the Ayeyarwaddy region in 20112. The survey includes an assessment of the project road.

30. The condition assessment (criteria not known) shows that 58% and 11% of the paved and unpaved roads respectively were in "good" condition.

31. The data in Appendix D also shows that the project road sections, Maubin to Kyaiklat and Kyaiklat to Phyapon were rated as "good" for 14% and 0% of their length respectively, and that they were in "fair" condition for 57% and 100% of their length respectively. Based on the assessments made in October 2013, conditions have slightly worsened (good and fair percentages decreasing by 5% to 15% and "poor" increasing by approximately 10%) for the Maubin to Kyaiklat sections and significantly worsened for the Kyaiklat to Phyapon section where the percent of roads in poor condition was more than 50%.

b. Vehicle Fleet Characteristics

32. As can be seen from the data in Table II-3 below the growth in the vehicle fleet is significant. Much of that growth in recent years has been in the motorcycle fleet which represented 88% of the total fleet in 2012.

Table II-3 : Myanmar Registered Vehicle

Vehicle Type	2010	2011	2012	2012 % Distribution
Passenger Car	259,712	263,046	28,1575	7.9
Light Truck	27,623	29,173	29,478	0.8
Heavy Truck	36,355	38,053	41,075	1.1
Bus	20,717	20,065	19,522	0.5
Other	15,590	15,212	17,603	0.5
Motorcycle	1,880,986	1,933,673	3,153,201	88.1
Trawlergyi[9]	44,852	38,758	34,862	1.0
Machinery	9	428	720	0.0
Total	**2,285,844**	**2,338,408**	**3,578,036**	**100.0**

Source: PW.

[9] Trawlergyi is a simple 2-wheel tractor with a trailer (operator sits on the trailer and steers the tractor using long handle bars).

c. Road Accident Statistics

33. The figures presented in Table II-4 show a progressive improvement in the rate of accidents, with the fatality index of 7.2 accidents per 10,000 vehicles in 2012. The fatality index when expressed in population terms is worse (refer to last column of Table II-4), largely because the vehicle numbers, and by inference, the kilometers travelled by road users and road accidents, have grown at a much faster rate than the population. Given low vehicle ownership in Myanmar. the fatality index when expressed per 10,000 vehicles is probably a better indicator of the state of road safety in Myanmar.

Table II-4: Myanmar Road Accident Statistics (2006–2012)

Road Accident Data					Fatality Index	
Year	**Registered Vehicles (million)**	**Number of Accidents**	**Number Injured**	**Number of Deaths**	**Per 10,000 vehicles**	**Per 100,000 population**
2006	0.98	6,778	11,385	1,362	13.7	2.46
2007	1.02	6,939	12,358	1,638	14.9	1.65
2008	1.99	6,483	11,558	1,778	8.9	3.04
2009	2.07	7,535	13,280	1,845	8.9	3.13
2010	2.3	7,965	14,230	2,264	9.85	3.82
2011	2.33	8,568	15,316	2,495	10.7	4.16
2012	3.7	9,339	15,720	2,653	7.2	4.42

Source: PW

34. Table II-5 reports the number of accidents by vehicle type. It also includes the results of a simple analysis that provides an indication of the vehicles that are most involved in road accidents. Of note, is the fact that while motorcycles make up approximately 88% of the vehicle fleet, they are only involved in approximately 50% of accidents. It is also worth noting that motorcycles are banned in Yangon which means that most are located in the regions, a fact reflected in the traffic survey count data from the project road which showed that 71% of the vehicles were 2-wheel motorcycles.

35. All vehicle types, except for motorcycles, are overrepresented in the statistics when compared with their number in the national vehicle fleet (refer to Table II-3).

Table II-5: Accident Numbers by Vehicle Type

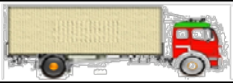
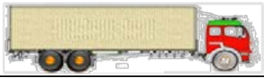
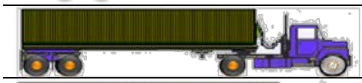
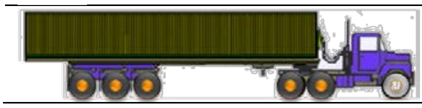
	2011 Numbers			2012 Numbers			2012 % Distribution		
Vehicle Type	**Accidents**	**Injury**	**Deaths**	**Accidents**	**Injury**	**Deaths**	**Accidents**	**Injury**	**Deaths**
Passenger Car	1,299	2,514	295	1,452	2,602	349	15.6	16.6	13.3
Truck	1,031	1,855	451	1,117	1,664	470	12.0	10.6	17.9
Bus	745	2,421	256	699	1,909	234	7.5	12.2	8.9
Others	71	82	40	91	150	45	1.0	1.0	1.7
Motorcycle	4,145	6,321	989	4,877	7,443	1,151	52.4	47.4	43.9
Three Wheelers	115	208	28	166	398	43	1.8	2.5	1.6
Trawlergyi	528	1,004	234	519	1,146	199	5.6	7.3	7.6
Machinery	585	784	176	385	377	132	4.1	2.4	5.0
Total	8,519	15,189	2,469	9,306	15,689	2,623	100.0	100.0	100.0

Source: PW

d. Axle Load Legal Limits

36. Axle load limits are in Table II-6. The damaging factors shown assume that trucks will be empty for 40% of their trips, which means that the damage caused on these trips is minimal. For example, the ESAL of a 3 axle unload truck is 0.18, while that for a legal loaded truck is 3.6. Distinguishing between loaded and unloaded is, therefore, necessary as the resulting average ESAL (Damaging Factor in Table II-.6 below) is applied to the total volume (loaded and unloaded) of each of truck type.

Table II-6: Allowable Loads by Vehicle Type

Truck Type	Axle and Wheel Configuration	Total Allowable (Tons) (Before 2015/ After 2015)	Post 2015 Damaging Factor if Legally Loaded (ESAL)	Damaging Factor if 15% overloaded (ESAL)
	2 axles, 6 tires	16/15	1.88	3.3
	3 axles, 10 tires	23/21	2.25	3.9
	4 axles, 12 tires	30/25	3.2	5.5
	4 axles, 14 tires	33/31	3.9	6.8
	5 axles, 18 tires	46/45	6.9	12.0
	6 axles, 22 tires	51.5/48	5.8	10.1

ESAL = equivalent single axle load.
Source: Prepared by Consultant based on data provided by PW

e. Road Network Funding

i. Total Public Works-managed Road Network

37. Road funding data in Table II-7 shows that the level of spending on roads in 2012–2013 was almost 4 times that in 2009–2010. It also shows that there is heavy expenditure on rehabilitation and special maintenance. While there was no detailed information on the condition of the overall road network, PW engineers have indicated that the cycle between significant repair and rehabilitation works can be as short as a few years. This is because many roads had been constructed informally and were subsequently upgraded without correcting deficiencies in the underlying road foundations and embankment. This is reported to be the case with the project road.

38. Lack of funding, to date, has also meant that the road works were generally corrective works designed to improve ride quality, by adding water bound macadam and/or penetration macadam overlays over a failed area or depression. The underlying problems were not corrected.

Table II-7: Road Budget for Roads Managed by Public Works (in million Kyats)

Work Category	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014 (budget)
Capital Works Total	106,477.665	257,087.403	473,660.566	393,278.530	191,723.657
Government Funds	106,477.665	257,087.403	473,660.566	393,278.530	141,277.307
External Funds	-	-	-	-	50,446.350
Road Upgrading/ Rehabilitation	106,477.665	257,087.403	473,660.566	393,278.530	191,723.657
Maintenance and Repair Total	26,596.800	27,739.683	87,154.387	103,292.272	69,371.556
Special Maintenance	19,659.481	21,792.075	87,154.387	98,572.59	63,572.181
Periodic Maintenance	0.000	0.000	0.000	0.000	0.000
Routine Maintenance & Repair	6,937.319	5,947.608	-	4,719.682	5,799.375
Equipment Purchases	1,791.490	1,745.261	1,924.634	2,009.400	Not provided

Work Category	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014 (budget)
PW Salaries and Operating Expenses (Head Office, Districts, etc.)	8,159.600	11,678.400	9,280.400	13,170.000	Not provided
Per diems and Travel Expenses	141.500	138.900	92.300	376.900	-
Total	143,167.055	298,389.647	572,112.287	512,127.102	261,095.213
Rehab and Special Maintenance	126,137.146	278,879.478	560,814.953	491,851.12	255,295.838
Routine Maintenance	6,937.319	5,947.608	-	4,719.682	5,799.375
Equipment and Overheads	10,092.590	13,562.561	11,297.334	15,556.3	-

PW = Public Works.
Source: PW

39. Table II-8 shows the expenditure per km of road network as reported in Table II-1 and II-2. The figures appear to be relatively high given that a large percentage of the roads are unsurfaced, indicating the poor state of the road network and the need for a large work program to clear the backlog of work and bring the road network back to a manageable state.

Table II-8: Costs/kilometer of Public Works Road Network ($ million)

Work Category	2011/12	2012/13	2013/14 (budget)
Total	15,563	13,469	6,865
Rehab and Special Maintenance	15,255	12,934	6,711
Routine Maintenance	0	125	154
Equipment and Overheads	308	410	

Note: Original figures were in Kyat; were converted to $ millions at October 2013 exchange rate.
Source: Consultant's calculations based on PW data.

3. Road Network in Ayeyarwaddy Region

40. Table II-9 below summarizes the expenditure on the 2,547 km that make up the road network in the region. Like the overall budget for roads, the budget in the Ayeyarwaddy region has increased between 2009 and 2013.

Table II-9: Ayeyarwaddy Road Network Budget (in million Kyat)

Work Category	2009/10	2010/11	2011/12	2012/13	2013/14
Capital Works (rehabilitation)Total	445.00	172.50	30.0	100.00	800.00
Maintenance and Repair Total	646.66	577.37	2,348.71	3,586.41	2,695.26
Special Maintenance	518.07	461.00	2,348.71	3,493.09	2,610.74
Periodic Maintenance	-	-	-	-	-
Routine Maintenance & Repair	128.59	116.37	0	93.32	84.52
Equipment Purchases	No data	No data	No data	No data	No data
PW Salaries and Operating Expenses	No data	No data	No data	No data	No data
Total	1,091.66	749.87	2,378.71	3,686.41	3,495.27
Capital Works	445.00	172.50	30.00	100.00	800.00
Rehab and Special Maintenance	518.07	461.00	2,348.71	3,493.09	2,610.74
Routine Maintenance	128.59	116.37	0.00	93.32	84.53

PW = Public Works.
Source: Consultants calculations based on PW data

41. Table II-10 shows the expenditure per km of PW managed roads in the Ayeyarwaddy region. As will be noted the level of expenditure per km is approximately 10% of the national per km expenditure.

Table II-10: Costs per Kilometer of Ayeyarwaddy Road Network ($/km)

Work Category	2011/12	2012/13	2013/14 (budget)
Total	961	1,489	1,412
Capital Works	12	40	323
Rehab and Special Maintenance	949	1,411	1,055
Routine Maintenance	0	38	34

Source: Consultants calculations based on PW data.

f. Road Network Maintenance

42. The data provided in Tables II-7 to II-10 above indicate that actual maintenance works are very limited, with most tasks being temporary and semi-permanent corrective and/or repair works, which are expensive and have a short life. These works are largely reactive and occur when areas of pavement have failed.

43. While the present reactive maintenance strategy is expected given the reported condition of the network, and the low level of investment in the past, PW needs to develop a more proactive policy that includes a strong preventive component that focuses on the roads that are in average to good condition and where preventive strategies will be effective in extending the life and performance of pavements. International experience, especially in developed countries where preventive maintenance strategies have been in place for some time, indicate that these strategies have had the effect of delaying the need for rehabilitation and reconstruction works for 5 to 10 years.

44. In developed countries, road managers have also adopted a long life pavement design strategy as this extends the time between rehabilitation and strengthening works and, when combined with preventive maintenance treatments such as sprayed seals, will extend the time even further. The result is better road conditions, significantly less impact on road users and safer road conditions. These benefits only come about if road managers (like PW) are able to identify early signs of a problem, have a wide range of maintenance treatments available, and can take action when needed. Delaying treatment normally means that the problem increases and the required treatment is more extensive and more expensive.

D. Other Road Project Initiatives

45. Investigations to identify other road sector initiatives have not been extensive. There are, however, reports of joint efforts with neighboring countries to build connecting road that will improve connectivity across Myanmar. There are also proposals from Japan and South Korea to develop specific road links.

46. Current projects of particular relevance include two initiatives that are being implemented as part of the Japan International Cooperation Agency (JICA) funded Improvement of Road Technology in the Disaster Affected Area of Myanmar Project. This project, which has 2 parts, is of direct relevance to the proposed ADB project as it is in the same geographic area, and will introduce new pavement and road surfacing technology, some of which is also proposed for the project road. The 2 parts of the project are as follow:

(i) Developing standards and manuals for designing and constructing road, including new technologies and the use of alternate materials (to be based on Japanese documents). The Government of Japan is also to provide a soil stabilizer machine that will be used initially in trials on a number of road sections (total of 3 km), and later by a PW Special Construction Unit that will rehabilitate and/or construct roads in the delta area using improved methods and the newly introduced technology. The JICA team consists of engineers reportedly from the Japan Ministry of Construction who are involved in developing manuals, identifying the appropriate trial sections and conducting a material testing program to identify suitable mix designs and pavement structures. They will also be available over the next 2 years to provide technical support to the MOC during construction; and

(ii) testing alternate and/or improved surfacing layers. It was not clear what these might be as the team (from the Japanese Road Association) had not arrived as is this report was being prepared. They will develop a manual and specification for the proposed treatments which they will test on sections of the road between Maubin and Bogale that runs in a south westerly direction from Maubin.

E. Construction Industry Capability

47. While the required road upgrading works are seemingly very simple, there are a number of issues that will present a challenge. These include the winning and transport of construction materials ranging from embankment material to pavement layer materials, some of which will need to be sourced 300 km north of the project area. Many of the materials will also need to be improved and/or modified before they can be incorporated into the road. This will mean the introduction of a new approach and method of construction, and the management of construction material supply and production and/or modification.

48. Discussions and investigations indicate that while the local construction industry has capability with building construction they have limited capability in road construction, and that which they do have is not current. Most of the contracting companies are companies within a development group, and therefore, do most of their work for that group. The few tender documents that have been sighted show that the industry and consultants are in their early stage of development as they rely heavily on MOC standards, design procedures, and even cost estimating procedures. The one priced bill of quantities (BOQ) that has been examined, with accompanying unit price calculations, indicate that the industry does not have a good knowledge of cost estimating, in a competitive environment. This latter comment is based on an examination of cost calculations where the contractor used only 3 different equipment hire rates, with the same rate used for a roller and for an asphalt plant. The resulting unit rates were, therefore, not reliable and could not be used for preparing the project's cost estimates.

III. PROJECT ROAD

A. General

49. The project road is located on a low embankment that is 0.7 m to 1.5 m above ground level. The road is flanked by canals that will generally impact on construction for the northern 30 km. The presence of rice paddy fields that start at the toe of the road embankment will be a factor as the road works will be constructed over a strip of land that is flooded for a good part of the year.

50. The road starts at a T-intersection on the fringe of Maubin. It is initially a gravel (water bound macadam) road for the first 1 km, up to the intersection with the Maubin bypass road. Beyond this point, the paved surface is approximately 6.5 m and then 5.5 m wide up to Km 32.1, the northern boundary of Kyaiklat Township through which the paved surface is approximately 4.5 m in an urban environment with cross streets and cross drains. The town section continues to Km 35.2 after which the paved surface is approximately 5.5 m. This continues to Km 53.2, the northern boundary of Phyapon town. Beyond this point the project road continues for a further 1.25 km. The paved surface width in the urban area is also approximately 5 m.

51. The road has not been overtopped by floods since records have been kept, although it was close to being overtopped in a few locations south of Kyaiklat during cyclone Nargis in 2008. The water levels at this time were the highest since records have been kept.

52. An underground communications cable located in or adjacent to the road embankment will mean that the road will need to be moved to one side by approximately 3 m, except at the larger bridges, where MPT will relocate the cable.

B. Applicable Road Standards

53. The MOC road width standards are in Table III-1. The proposed standards for the project road by road section are presented in Table III-2. While the road width standards for the rural sections are based on Table III-1, those in the two urban sections are governed by the width possible through the narrow section of Kyaiklat where it is proposed that the project limit itself to the reconstruction of the traffic lanes and gravel shoulders. The town authorities could build kerbs and/or footpaths or concrete shoulders, at a later stage.

Table III-1: Myanmar Road Standards

Road Class	Vpd	Unit Type	Formation	Traffic Lanes (each side)	Shoulder (each side)
D4 Road (existing Class)	200 to 500	Imperial	34.0	9.0	8.0
		Metric	10.3	2.7	2.4
D3 Road	500 to 2500	Imperial	40.0	12.0	8.0
		Metric	12.1	3.6	2.4
D5 Road (existing Class)	500 to 2500	Imperial	32.0	8.0	8.0
		Metric	9.7	2.4	2.4

Source: MOC Road Standards

Table III-2: Proposed Standards by Road Section

Road Section (km)	Proposed Standard	Formation (ft / m)	Traffic Lanes (ft / m)	Paved Shoulder (ft / m)	Unpaved Shoulder (ft / m)
0 to 30.2 (Kyaiklat)	D3 modified	37.5 (11.4)	10.75 (3.3)	6 (1.8)	2(0.6)
30.2 to 31.7(Kyaiklat)	Existing formation width	23 (7.0)	11.5 (3.5)	Town Authorities	NA
31.7 to 33.2	Pavement of	23 (7.0)	11.5(3.5)	Town	NA

Road Section (km)	Proposed Standard	Formation (ft / m)	Traffic Lanes (ft / m)	Paved Shoulder (ft / m)	Unpaved Shoulder (ft / m)
	traffic lanes only			Authorities	
33.2 To Phyapon	D3 modified	37.5 (11.4)	10.75 (3.3)	6 (1.8)	2(0.6)

ft = feet, m = meter, NA = not applicable.
Source: Prepared by Consultant, based on MOC data.

54. The proposed road width for the rural road sections is a slightly narrower (0.7 m [2.5 feet]) D3 standard, in order to reduce costs. Although slightly narrower, the full width pavement and sealed shoulders of the proposed road will encourage pedestrians, non-motorized traffic, and stopped vehicles to use the shoulders, thus increasing road capacity and road safety.

C. Project Road for Government Funding

55. The government funding of the project road is indicated in Table III-1 below. The expenditure per km of road expressed in $, at the current rate, is shown in Table III-2. A comparison with Table II-8 will show that the expenditure on the project road has been well below the average for the PW-managed roads but above the expenditure for the PW-managed roads in the Ayeyarwaddy Region.

Table III-3: Total Expenditure on Project Road (in million kyat)

Work Category	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014 (budget)
Total	1,211	559	220	165	419
Capital Works	0	0	0	0	0
Rehab and Special Maintenance	1,175	445	172	165	419
Routine Maintenance	36	114	48	0	0

Source: Prepared by Consultant, based on MOC data.

Table III-4: Expenditure/Kilometer on Project Road ($)

Work Category	2011–2012	2012–2013
Total	4,271	3,203
Capital Works	0	0
Rehab and Special Maintenance	3,339	3,203
Routine Maintenance	932	0

Source: Prepared by Consultant, based on MOC data.

D. Project Road Details

1. Physical Characteristics

56. The present road is a rough macadam-surfaced two-lane road on a low embankment (0.5 to 1.2 m above the natural surface with a paved surface that varies between 5.5 m to 6.6 m) with earth shoulders that are reported to be between 2 m and 4 m on each side, but are in-fact, too steep a slope to be considered shoulders (often 10 to 20% slope). Road conditions range from fair to very poor with estimated roughness levels (international roughness index [IRI]) of 6 to more than 15. Road surface is deformed and has failed along most sections for at least 25% (and as high as 80%) of the paved area. The failures are mostly in the outer 1 m to 1.5 m from the paved edge. (Refer to Appendix A for the results of the road condition assessment and Appendix C for the results of the road work needs assessment).

57. The road is located in flat terrain that is heavily cultivated and is crossed by many rivers, creeks and irrigation canals, two of which parallel the road for a significant length.

While clear of the road and any proposed works, the canals would be a factor in the moisture content of the road embankment and adjacent land. Of more significance is the presence of rice paddy which starts at the base of the road embankment. Road widening will require a widened embankment to be constructed over a strip of paddy fields which will need to be prepared and compacted, where possible, before this can be done.[10] The MOC will need to ensure that these paddy fields are not used (irrigated) in the months preceding the road construction.

58. The IRI along the road ranges from 6 to more the 15, the latter being in the section south of Kyaiklat.

59. Appendix B includes a summary of geotechnical investigations and material testing carried out during the study and a copy of the soil stabilizing results from a JICA-funded project, referred to above.

2. Ground and Subgrade Conditions

a. Overview

60. The geotechnical investigation carried out during the project was less than ideal and was designed to supplement and/or verify the testing program carried out in 2003 and 2006 (refer to Table III-5) by MOC PW. Unlike the earlier studies, which focused on establishing the condition of the road embankment, with test pits every 160 m, the project study also included an assessment of ground conditions beside the present road embankment. This is the area on which a widened embankment would be constructed.

b. Discussion of Previous Study Results

61. The two studies, while extensive, lack some data that would have made some of the data more meaningful. For example, in-situ density and moisture content at some of the Dynamic Cone Penetrometer (DCP)[11] locations would have made the results more useful as DCP results are heavily influenced by moisture content and density (refer to Table III-5).

62. On the plus side, the data provides the following information:

(i) soils (in the embankment and adjacent possible borrow areas) are primarily high plasticity silty clays with as CBR of 2.5 to 3% after being soaked for 4 days;
(ii) June/July moisture contents in the road embankment are significantly dry (5 to 6%) of optimum moisture content (OMC);
(iii) DCP tests indicate that while there is a stronger layer found 200 to 400 mm below the surface the material below this layer is much weaker. It is also generally weaker than the top 200 mm; and
(iv) density of the fill material varies from 82 to 90% of modified maximum dry density (MDD) with most being lower than 86% modified compaction.

[10] Where water is present the contractor, will need to remove the most of the saturated layer before placing the sand fill, which will need to be placed in a controlled manner so that the fill displaces the water.
[11] DCP is an in-situ strength testing probe. Depths of penetration per blow (drop weight falls a defined height) can be converted to a CBR.

Table III-5: Summary of 2003 and 2006 Geotechnical Investigations

Study Date	Item	Road Section	Pavement Thickness	In-situ Density & Moisture	CBR from DCP	Laboratory Tests
2003 Field Work during June/July of 2003	Work Done	Km. 13 to Km. 52.5.	Recorded at 160 m intervals	NO		5 Samples (possible borrow)
		Km. 14.3 to Km. 32.1			Recorded at 160 m intervals	
	Summary of Results		20 cm to 35 cm Average – 25 cm of Crushed Rock	Not Recorded	Depth: 0-200 mm = 4% to 9% Depth: 200-400 mm = 8% to 18% (some 3 to 7%) Depth: 400mm plus = <6% (3 to 15)	CH Soil (3) PI = 33%; CBR_4 =3% CL Soil (2) PI = 20% CBR_4 =3.5%
2005 Field work during June/July of 2005	Work Done	0 and 17	Recorded at 160 m intervals	Recorded at 160 m intervals.	NO	2 Samples
	Summary of Results		16 to 30 cm Average – 20 cm of crushed rock	Density: 82% to 90% (average = 86%) Field Moisture Content = 10% to 11.5%		CH Soil PI = 30%; CBR_4 =2.5% OMC=19%

CBR = California bearing ratio, cm = centimeter, DCP = dynamic core penetrometer, km = kilometer, m = meter, mm = millimeter, OMC = optimum moisture content.
Source: Prepared by Consultant, based on MOC RRL data.

c. Discussion of Present Study results

63. The results from the geotechnical investigations and associated material testing are detailed in Appendix B. Unlike the earlier studies, there were only a limited number of test pits excavated in the road itself, typically at 9 km intervals. The results are summarized in Table III-6.

64. The roadside investigations were similarly widely spaced with test pits on each side of the present road embankment at intervals of 8 km. Because of the presence of water, the test pits were excavated close to the toe of the road embankment.

65. The data provides the following information:

(i) soils in and beside the road embankment are high plasticity silty clays with a CBR of 2 to 3% (as low as 1%) after being soaked for 4 days and 1% when soaked for 7 days;

(ii) moisture contents in the road embankment are generally 22% to 34%, and, therefore, well wet of the OMC which is around 13% to 16%. It is expected that the higher moisture contents are in areas where the existing road surfacing was cracked and that they would probably be lower in areas where the surfacing was intact. Irrespective of this, the in situ moisture contents are up to 100% higher than OMC. While moisture contents were not recorded, similar soils compacted to 90% of MDD, after 4 days of soaking, would be 5% to 7% higher than OMC based on tests carried out in other countries. It is, therefore, likely that the in-situ CBR was around 2% during September and possibly much of the wet season;

(iii) moisture contents recorded in the test pits at the toe of the embankment were between 23% and 38%, with most readings being higher than 30%. This is not surprising given the location of the test pits which were close to paddy fields. It will clearly not be possible to compact the embankment foundation for 2 to 3 months after the wet season, unless water is removed from the paddy fields;

(iv) DCP tests recorded during the current investigations in the road formation are surprising as they indicate an increase in strength with depth. This was not the case in the more detailed program of DCP testing carried out in 2002/03 where the soil strengths decreased with depth;

(v) DCP testing at the toe of the embankments show that there is a weak layer of approximately 300 mm, over a stronger layer. This is surprising as the alluvial deposits in the delta are reported to be more than 50 m deep and given the standing water on the ground surface and high water table, it was expected that the layers below the upper layer would be of similar strength to that near the top, possibly slightly stronger, as the upper layer is likely to have been disturbed. The results here, as for those in the road formation itself, could also indicate that water entry into the road and pavement structure may be from the surface rather than from a high water table; and

(vi) density of the fill material varies from 84% to 94% of modified MDD with 60% of the results being lower than 90% modified MDD, the specified density for embankments.

Table III-6: Summary of 2013 Geotechnical Investigations (Roadside)

Study Date	Item	Road Section	Pavement Thickness	In-situ Density & Moisture	CBR from DCP	Laboratory Tests
2013 Field work September	Work Done	Km 0 to Km 32.1.	Not Recorded	Recorded	Recorded	8 Samples
		Km 32.1 to Km 35.2	Not Recorded	Recorded	Recorded	2 Samples
		Km 35.2 to Km 52.5	Not Recorded	Recorded	Recorded	4 samples
	Summary of Results	Km 0 to Km 32.1.		Density = 80% to 92% (average = 87% Field moisture content = 23% to 34% (average = 28%)	Depth: 0-200mm = 2% Depth: 200-400mm = 5% (some 10%) Depth: 400 mm plus = 10% (15%)	CH Soil PI = 32%; CBR_4 =2% (2 samples)
		Km 32.1 to 35.2		Density = 84% to 86% (average = 85% Field moisture content = 30% to 32% (average =	Depth: 0-200mm = 2% Depth: 200-400mm = 8% Depth: 400 mm plus = 14%	No test

Study Date	Item	Road Section	Pavement Thickness	In-situ Density & Moisture	CBR from DCP	Laboratory Tests
				31%)		
		Km 35.2 to 52.5		Density = 80% to 92% (average = 85% Field moisture content = 30% to 38% (average = 34%)	Depth: 0-200 mm = 2.5% Depth: 200-400 mm = 10% Depth: 400 mm plus = 12% % to 24%	CH Soil PI = 42%; CBR_4 =3% CBR_7 =1%

CBR = California bearing ratio, DCP = dynamic core penetrometer, km = kilometer, mm = millimeter.
Source: Prepared by Consultant, based on MOC RRL data.

Table III-7: Summary of 2013 Geotechnical Investigations (Existing Road)

Study Date	Item	Road Section	Pavement Thickness	In-situ Density & Moisture	CBR from DCP	Laboratory Tests
2013 Field work September	Work Done	Km 0 to Km 32.1.	Not Recorded	Recorded	Recorded	3 Samples
		Km 32.1 to Km 35.2	Not Recorded	Recorded	Recorded	1 Samples
		Km 35.2 to Km 52.5	Not Recorded	Recorded	Recorded	4 samples
	Summary of Results	Km 0 to Km 32.1.		Density = 90% to 99% Field moisture content = 23% to 30% (average = 26%)	Depth: 0-200 mm = 3% to 7% Depth: 200-400 mm = 6% to 9% Depth: 400 mm plus = 6% to16%)	CH Soil PI = 37 to 50%; CBR_4 =2 and 3% CBR_7 =1%
		Km 32.1 to Km 35.2		Density = 93% Field moisture content = 22%	Depth: 0-200 mm = 19% Depth: 200-400 mm = 8% Depth: 400 mm plus = 17%	No test
		Km 35.2 to Km 52.5		Density = 84 to 94% (average = 88% Field moisture content = 25% to 31% (average = 28%)	Depth: 0-200 mm = 6 to 8% Depth: 200-400 mm = 18% Depth: 400 mm plus = 14% to 26%	Cal Soil PI = 14%; CBR_4 =5% CBR_7 =1%

CBR = California bearing ratio, DCP = dynamic core penetrometer, km = kilometer, mm = millimeter.
Source: Prepared by Consultant, based on MOC RRL data.

3. Road Foundation and Use of Existing Road Fill

a. Road Foundation

66. The road will be widened to one side, as a general rule. That widening will require approximately a 4 m to 5 m strip of land to be prepared, as the embankment foundation, before the road embankment can be constructed. The foundation area will need to be stripped of its top soil (20 cm), as will the batter and shoulder of the existing road embankment on the side of the widening. Following the removal of top soil, any unsuitable material (containing organic matter or still too wet) found in the foundation area and existing exposed embankment should be removed and replaced with a material with a CBR (4 day soaked) of at least 3%. The underlying soil in the foundation area and toe of embankment should then be scarified (if conditions allow) to a depth of at least 250 mm and compacted to a density of 90% MDD (modified).

b. Using Existing Embankment Material

67. The existing embankment is of variable quality and would normally be considered marginal given that its CBR at the in-situ moisture content prevalent during approximately 6 months of the year, as a minimum is likely to be 2% or less. The material is also highly plastic with linear shrinkage of between 11% and 15%.

68. While the test results do appear to indicate areas of better quality material, it would be safer to assume that the existing embankment soils: (i) will only be used as lower fill or be mixed with locally available silty sands (75% sand and 25% soil) to produce a fill material with a CBR of at least 5%; or (ii) <u>modified</u> with lime (2.0 to 2.5%) to produce a CBR 7% or better fill material.

69. The silty sands with a CBR of at least 5% are also a possible fill material provided the material can be clad at the outer slopes of the embankment with a clay soil layer of at least 30 cm.

70. If the limited DCP test results are correct in may even be possible that borrow pits excavated along the road could provide materials with a CBR of at least 5%.

c. Embankment and Subgrade

71. The embankment fill material will be sand (with cladding to prevent erosion) that will be built up to the level indicated in Figures 1 and 2, where details of proposed subgrade are given.

72. A subgrade CBR (4 day soaked) of 5% has been adopted in the design

d. Pavement Structure Materials

i. Subbase

73. The proposed subbase layer is to consist of river gravel (shingle), sand, soil blend with a 4 day soaked CBR of 30% and a maximum PI of 6%. Other possibilities include stabilizing the sand soil blend proposed for the improved subgrade above. Refer to Table III-8.

ii. Base Material

74. While it is theoretically possible to produce a base course by stabilizing low quality

soils, it is good practice to start with a material that is of subbase quality. This is especially important as stabilized pavement layers tend to crack, especially ones with a high percentage of stabilizer, and while this does not affect a stabilized layer's performance to any large degree, the cracks will allow the entry of water into the pavement structure and will weaken it.

75. Given that suitable subbase quality materials is not readily available, the only real option is a dense graded crush rock base that will be produced by blending 3 commercially available size fractions (10 mm to 25 mm, 6 mm to10 mm, and crushed dust).

Table III-8: Summary of 2013 Construction Material Investigations

Possible Material	Subbase	Improved Fill or Subgrade	Comments
CL Soil (soaked CBR 3%) stabilized with lime	Not Suitable	Suitable. Would need approximately 3% lime	Local soils from the existing road embankment or beside the road
Shingle/soil blend	Suitable but would need to check the PI	Suitable	Shingles are coarse sand/fine gravel won from the Ayeyarwaddy River – the best quality is from between Hinthada and Zalun
Silty sand/soil stabilized with lime	Suitable. Would need approximately 5% lime or 4% of cement (additive used would depend on soil/ sand ratio)	Suitable. Would need approximately 2% lime or 2.5% of cement (additive used would depend on soil/sand ratio)	Silty sand is sourced from rivers and streams close to the project road
Silty sand stabilized with cement or lime	Suitable. Would need approximately 4% lime or 3% of cement (additive used would depend on soil/sand ratio	Suitable. Would need approximately 3% lime or 2% of cement	As above
Lateritic gravel (sighted on roads only)	Possibility that needs to be investigated	Suitable	Located approximately 50 km north east of Phyapon.
Weathered Rock (Myaung Mya)	Suitable. Hardness could be an issue. May need to be crushed by project contractor	Suitable. May need to be crushed by project contractor	Rocks appear to be variable and often fail Crushing Value, and absorption requirements for a subbase. Can also be close to the limit for Los Angeles abrasion test requirement also.

CBR = California bearing ratio, km = kilometer.
Source: Prepared by Consultant

76. Test results show that the normal sources of crushed rock are of a suitable quality. Typical Test results are summarized in Table III-9.

77. As will be seen from Table III-9, the quality of the crushed rock and shape are acceptable. The test results for the larger aggregate sizes (30 mm to 50 mm) are very similar.

78. There is, however, a question over the grading. Existing fine aggregate, referred to locally as chippings, are not single sized and would need to be screened, by the construction contractor, with the unwanted fractions being incorporated into the base course.

iii. Surfacing Materials

79. The aggregate materials for road surfacing found in the project area, and likely to be available for use in future contracts, were found to be suitable for use as sealing aggregate in asphalt concrete seals, as can be seen in Table III-9.

Table III-9: Base and Surfacing Test results and Specification Requirements

Source	Specific Gravity	Absorption (%)	Clay Lumps	Crushing Value	Los Angeles Abrasion	Flakiness (%)
Pyay-KaMyaing 20 max chipping (sample from Phyapon)	2.8	0.8	0.2	20	20	3.6
Mandolay Htonebo 20 max chipping (sample from Phyapon)	2.8	0.7	0.5	28.6	32.1	12.9
BS Surfacing Specification	2.5 to 3.0	2.0 max	2.0 max	30 max	40 max	30%
BS Base Specification	2.5 to 3.0	4.0 max	4.0 max	30 max	50 max	40%
BS Subbase Specification	2.5 to 3.0	4.0 max	4.0 max	40 max	50 max	40%

Source: Road Research Laboratory.

e. Environmental Conditions

80. As indicated the road is located in flat terrain and is surrounded rice paddy fields and a network of irrigation channels. There are 2 harvests per year which means that there is standing water beside the road for most of the year. The road is also located in a high rainfall area where flooding of the farm land beside the road is not uncommon.

4. Rainfall

81. Rainfall records at 3 locations along the road are summarized in Table III-10 below. As will be noted the wet season starts approximately in the middle of May and ends early to mid-October. Rain falls on approximately 120 days of the approximately 180 days within this period.

Table III-10: Summary of Rainfall Statistics (mm of rain recorded)

	Maubin				Kyaiklat				Phyapon			
	Annual		Number of Rain Days		Annual		Number of Rain Days		Annual		Number of Rain Days	
Months	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
January	0	No Data		No Data	0	0	0	0	0		0	0
February	0	No Data		No Data	0	0	0	0	0		0	0
March	9	No Data	2	No Data	0	0	0	0	16		1	0
April	0	No Data		No Data	0	0	0	0	12		1	0
May	202	No Data	13	No Data	38	158	5	13	174	19	10	15
June	515	No Data	24	No Data	617	360	19	22	693	715	24	24
July	581	No Data	22	No Data	571	1,006	21	28	594	972	24	28
August	787	No Data	28	No Data	882	523	29	22	1,016	518	30	25
September	339		22		486		21		413		19	
October	133		12		179		10		169		12	
November	7		6		64		4		226		8	

	Maubin				Kyaiklat				Phyapon			
	Annual		Number of Rain Days		Annual		Number of Rain Days		Annual		Number of Rain Days	
Months	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
December	15		1		25		1		13		1	
Totals	**2,588**	**0**	**130**	**0**	**2,862**	**2,047**	**110**	**85**	**3,326**	**2,224**	**130**	**92**

Source: PW District Offices in Maubin and Phyapon

5. Road Flood Locations

82. The District PW offices have advised that no portion of the road has ever been flooded. This was even the situation during the Nargis Cyclone in 2008, when water levels in the project area were at the highest level ever recorded.

83. Table III-11 below lists the cyclones that have impacted the delta area.

Table III-11: Major Cyclone Events

Cyclone Name	Year	Peak Surge (m)	Landfall Area
Sittwe	1968	4.25	Sittwe
Pathein	1975	3.0	Pathein (Ayeyarwaddy)
Gwa	1982	3.7	Gwa
Maungdaw	1994	3.66	Maungdaw
Mala	2006	4.57	Mala
Nargis	2008	7.02	Ayeyarwaddy, Yangon, Mon

m = meter.
Source: Myanmar Ministry of Agriculture and Irrigation Web Site

6. Low River Levels (North of Project Area)

84. Low river levels in the river systems, the Ayeyarwaddy and Chindwin rivers in particular, in central Myanmar means that goods cannot be shipped by water starting in late March or early April of each year. While some goods are transferred to smaller crafts, this will not be possible for the road construction materials normally sourced from the Pyay and Mandalay regions.

85. This annual event normally results in increased construction material prices. In 2013, the river levels dropped earlier with the effects on transport being felt in late February.

E. Traffic Characteristics

a. Traffic Volume and Pavement Design Traffic Load

1. Commercial Traffic Volumes and Characteristics

86. The traffic volumes and composition of traffic on the project road has been analyzed and are detailed in the economics report. The annual average daily traffic (AADT) in September 2013 was around 1,000, inclusive of motorcycles.

87. Of the above traffic, there were between 117 and 128 commercial vehicles as indicated in Table III-12, which also shows the vehicle damaging factor and projected growth rate for each vehicle type.

88. While the weighted average annual growth rate in traffic volumes is 7.2%, the growth in the annual weighted average damaging factor is 13.2%. This is because of the projected higher growth in the heavier vehicles.

2. Determination of the Design Traffic Load

89. Design traffic load, as used in pavement thickness design, is expressed as total ESAL. The design ESAL figure is the estimated cumulative application of axle loads over the specified design period, which is 10 years in Myanmar. The average ESAL per commercial vehicle type is shown in Table III-12. The steps required to determine the traffic design load are in Table III-13.

Table III-12: AADT Volumes, 2013

Vehicle Type	Damaging Factor (legally Loaded) (ESAL/vehicle)	Damaging Factor (l15% overloaded (ESAL/vehicle	Daily Traffic (Maubin to Kyaiklat)	Daily Traffic (Kyaiklat to Phyapon)	Annual Growth Rate (%)
Small Bus	0.15	0.28	13	12	14.7
Large Bus	1.60	2.80	50	46	4.0
Light Utility	0.15	0.28	16	15	11.3
Light Truck	0.50	0.88	29	27	7.6
Medium Truck	1.90	3.30	18	16.	3.5
Large Truck	2.25	3.90	1	1	17.1
Articulated Truck	6.90	12.00	1	1	17.1
Total Traffic			128	117	7.2
Weighted Growth Rate in ESAL					**13.2**

ESAL = equivalent single axle load.
Source: Prepared by Consultant based on Traffic Counts and Data provided by PW.

Table III-13: Calculation Steps to Determine Traffic Design Load

Step	Description	Action	Comment
1	Determine the daily ESAL	a. Multiply the vehicle volume of each vehicle per day by its respective damaging factor; b. Repeat (a) for all vehicles; c. Add the product of the above calculation to establish the ESAL/day	
2	Determine ESAL per year	Multiply the daily ESAL by 365	The ESAL is for 2 way traffic flow
3	Determine the traffic lane ESAL	Multiply the Annual ESAL by 0.7	Most design manuals recommend 0.55. In developing countries there is a tendency for trucks to drive with one wheel on or just over the centerline, hence the higher multiplier
4	Determine design traffic load for the adopted design period	This calculation uses the Annual ESAL, projected traffic volume growth rate and the adopted design life. The formula is: Design Traffic Load = (Annual ESAL X (1+decimal growth rate)^ design years -1) / growth rate	

ESAL = equivalent single axle load.
Source: Prepared by Consultant.

90. Table III-14 shows the traffic design load for 2 design periods and for two axle load scenarios, namely legally loaded and 15% overloaded.

Table III-14: Indicative Pavement Design Loading (million ESAL)

Design Period (years)	Maubin to Kyaiklat		Kyaiklat to Phyapon	
	Legal Loading	15% overloaded on each axle	Legal Loading	15% overloaded on each axle
10	1.0	1.7	0.9	1.7
15	2.2	3.8	2.0	3.5
20	4.4	7.7	4.1	7.0

ESAL = equivalent single axle load.
Source: Prepared by Consultant

b. Road Accidents

91. Table III-15 shows the accidents that occurred in 2012–2013. In most instances, there is one accident per accident location. There are two locations, highlighted in the table, where more than one accident has occurred with the curve located at Km. 8 identified as the location of a number of road accidents in a community meeting.

92. While cause of the accidents has not been identified in the data or discussions, road conditions are likely to be a contributing factor. This applies especially to the curve at Km. 8 where the radius is approximately 90 m.

Table III-15: Road Accidents on the Maubin to Phyapon Road, 2012–2103

Location of Individual Accident (km)		Injury		Death		
From	To	Male	Female	Male	Female	Comment
1.6	2.4	5				Motor Cycle
3.0	3.4	2				Vehicle
3.2	3.6	1				Motor Cycle
3.2	3.4	1				Vehicle/Motor Cycle
4.6	5.2	5		1		Vehicle
7.8	8.2	1				Motor Cycle
7.8	8.2	2				Motor Cycle
7.8	8.2		2			Motor Cycle
17.6	17.8	1				Motor Cycle
19.8	20.0	2	2			Motor Cycle
23.8	24.0	1	3			Motor Cycle
26.8	27.0	1				Motor Cycle
30.4	30.6	1	1			Motor Cycle
43.4	45.0	2	1			Motorcar
48.8	48.8			1		Motor Cycle
50.4	50.4		1			Motor Cycle
50.8	50.8	2	1			Vehicle
50.8	51.4	1		1		Motor Cycle
Total		**28**	**11**	**3**	**0**	

Source: Data provided by PW District Offices in Maubin and Phyapon.

F. Pavement Performance Problems

93. The existing embankment is low, is constructed from materials won from adjacent to the road with limited to no quality control during construction and is said to include organic material. This situation, combined with the high water table, low embankment densities, inadequate pavement thickness and poor drainage, go some way to explaining why the road surface is uneven and is reported to fail every few years.

94. The situation is not improved by the practice of constructing pavements that are flanked by shoulders constructed of impervious material. This means that the water that

enters the pavement cannot drain away, resulting in the saturation of the subgrade and pavement layers in the outer (from seal edge) 1 m to 1.5 m of the road pavement in each direction of travel. The failures seen in Figure III-1 result from this, and will extend over the full pavement width over time.

95. The other possible cause of failures, near the seal edge, may be due to the practice of constructing thinner pavements when widening has been carried out.

96. Actions that need to be taken to avoid a repetition of the above situation include:

(i) exposing the fill material, removing and/or replacing unsuitable material and compacting the existing fill and foundations for a widened road, prior to building the new road embankment;
(ii) using a select fill material (CBR 5% as a minimum) for a depth of 400 mm below the subbase – availability of better quality materials with a CBR of 15%, for example, would have the effect of reducing the thickness of more expensive pavement layers;
(iii) designing the pavement for the likely in-situ moisture conditions (this could mean soaking CBR samples longer than 4 days in the case of fill and subgrade soils). The proposed full width pavement construction, with sealed shoulders, as shown in Figure III-1 will mean that the pavement structure and the improved subgrade and/or capping layer will be drier than is the case at present;
(iv) incorporating a drainage layer into the embankment to intercept water rising from below or stabilizing part of the fill of lower pavement layer will act as a barrier to the upward movement of water. Use of a sand as the primary material fill and/or the stabilizing the in-situ soils with lime are strong possibilities together with a sand mixed with some soil;
(v) designing a pavement for the likely design loads. Anecdotal data suggest that trucks are often overloaded; and
(vi) ensuring pavement layer thickness, material quality and work quality are as specified and that that pavement structure drainage is not restricted.

Figure III-1: Project Road Pavement Failures

G. Existing Bridges

a. General

97. Existing bridges vary in both size and design with very few bridges having the same arrangement. This applies especially to the bridges over 7 m in length, where the bridges often have higher head clearance over water levels and, therefore, higher approach embankments that have settled and resulted in unsafe bridge approach conditions and exposed the ends of kerbs and handrails to vehicles that may deviate from the traffic lanes.

b. Bridge Characteristics

98. Appendix F summarizes the key bridge characteristic and the works that will need to be carried out to accommodate the road alignment relocations (because of the location of the underground telecommunication cable) and improve ride conditions at the bridges and make them safe. Types of work that will need to be carried out include:

(i) widening 3 bridges (possibly 4) and lengthening of 3 culverts, including new headwalls and wing walls;
(ii) raising the level of wing walls and increasing their length to retain the embankment that will be raised and slightly widened;
(iii) removing existing concrete guideposts and replacing with guard rails on the approach to bridges;
(iv) raising and lengthening the abutment returns to retain the raised road level on the approach to bridges; and
(v) deck repairs and some resurfacing on one bridge.

c. Mile 16 Bridge – the Oo Yin Chaung Bridge

99. The proposed works will include widened abutments, and a replacement superstructure, to consist of pre-stressed concrete girders and a concrete deck. A temporary structure will need to be constructed and the existing steel truss bridge removed before this work can start. Appendix F includes a general arrangement drawing for the bridge.

d. Kyee Chaung Bridge

100. This is a narrow one-lane bridge that is in poor condition and has a load limit of 13 tons.

e. Kyaiklat Township Bridge

101. The bridge is a wide single-lane road with a posted load limit of 13 tons but believed to be able to carry heavier loads. It was reconstructed in mid-2013. Bridge replacement and/or widening was proposed just prior to the preparation of this report so that it would have the same load carrying capacity as the other bridges on the road.

H. Road Construction Issues

102. The key issues relate specifically to the rehabilitation works and how they are impacted by site conditions, material availability, and the need to modify material properties.

(i) Source, type, and/or characteristics of material for road embankment, drainage layer, subbase, base and surfacing – a total of approximately 14,000 cubic meter (m^3) will be required per km for fill and pavement materials (equivalent to an average of 22,000 m^3 per month, assuming a 20–24 month actual construction period, excluding the wet seasons). Most of the materials will have to be imported and will need to be stockpiled and processed (blended) in a works area. Some could be processed on the road (mechanical and chemical stabilization). Some of the materials will come from as near as 20 km away and some from as far as 300 km away.

Issues: (i) ability of material suppliers and/or contractors to supply the required materials at a reasonable rate (m^3/day) is unclear as this will depend on the demand from other projects; (ii) there will be a need for a holding and/or work area to stockpile and mix materials before it is brought to the road; (iii) proximity of the river to the road means that there are a number of possible delivery sites that could be developed by the contractors near the river bank; and (iv) some will only allow smaller barges to be used because of lower river levels during the dry season.

(ii) The presence of the fiber optic communication cable in the road embankment (within 0.6 m [2 ft] of the present seal edge and approximately 1 m below the surface, for approximately 30 km (and 4 to 6 m from the centerline elsewhere) will be an issue, even though the road alignment will be moved by a few meters, as works will be carried out close to the cable. The cable also crosses the road in 5 locations. One of these locations is in Kyaiklat where it will not interfere with the proposed works;

Issue: MPT will need to move the cable at the agreed locations before the end of 2014. This will need to be managed by PW’s PMU. The contract documents will require the contractor to locate the cable before roadwork commencement.

(iii) The current mode of construction in Myanmar is not suited to modern road rehabilitation. This is only an issue if less sophisticated contractors are successful or play a major role on the works.

Issue: Materials are presently deposited on the road edge over weeks and months. This will not be possible on the project road as it is necessary to compact, and partially reconstruct, the existing embankment after salvaging the existing crushed rock pavement. The contractors will need to establish construction material stockpiling sites where materials can also be modified and blended as required. These sites would need to be close to the river as pavement materials are likely to be delivered by water transport;

(iv) Wet conditions in area on which a widened road embankment will be reconstructed.

Issue: Rice is grown immediately adjacent to the toe of the road embankment during parts of the dry season. As the proposed earthworks will extend into the paddy field, the embankment foundation area should be dry, although it is not clear whether this will be possible along some parts of the road. PW will need to ask farmers not to flood the road side paddy field at least 2–3 months before road works start, where possible. There would, however, appear to be locations where this might not be possible, which means that controlled placement of fill will be required after organic material has been removed from the embankment foundation area. Achieving the required level of compaction to minimize settlement may be difficult. A staged approach to road construction will be necessary with traffic directed over the widened portion for an extended period, including 1 wet season;

(v) Limited road material investigation and quality control laboratory capacity.

Issue: Most private laboratories are set up for foundation related investigations and concrete testing. Project contractors will be required to establish laboratories in the project area. Laboratory equipment should then be transferred to the MOC for equipping their central and/or regional laboratory.

IV. PROPOSED ROAD AND BRIDGE DESIGN

A. General

103. This section of the report deals with the key design proposals, primarily for the roadworks, as the design for the bridge Oo Yin Chaung (Mile 16) was completed by PW Bridge Department.

B. Road Alignment

104. The proposed road alignment, which generally follows the existing road alignment, is relatively good as would be expected in the flat terrain. There are, however, a few issues:

(i) a curve at approximately Km 8 that is the site of a number of accidents – the radius will be increased. The need to stay within the ROW will limit the size of curve possible. It will possibly be necessary to have additional signage, line markings, and rumble strips on the approach to this curve;
(ii) the present vertical alignment on the approach to 8 bridges is poor, reduces the sight distance and forces vehicles to slow to approximately 10 km per hour at each bridge approach. The proposed vertical profile design will smooth out the alignment to eliminate an unsafe situation. This will require the construction of a low retaining structure on the existing road formation to retain the raised road;
(iii) the road will be raised by 300 mm to 400 mm, except for the 2 urban road sections where existing services will control road levels; and
(iv) the presence of the underground cable within or immediately adjacent to the road embankment means that the road alignment will be moved laterally by approximately 3 m except in 8 locations (on the approaches to medium and large bridges) were the MPT has agreed to relocate the cable. This will mean that reverse curves will need to be incorporated into the alignment at each of these locations. Alignment changes will also be necessary at 2 of the 3 locations were the underground cable crosses the road.

C. Road Safety Improvements

105. The proposed road safely improvements include:

(i) usable sealed shoulders that will:
- encourage pedestrians and nonmotorized traffic to travel on the shoulders and not the traffic lanes;
- encourage stopped or broken down vehicles to use the shoulder, leaving the traffic lanes free for use by moving vehicles;
- provide additional width for a vehicle that loses control, to regain control, and return to the traffic lanes; and
- ensure that shoulder maintenance needs are minimized as the unsealed shoulder and seal edge are well away from the traffic. Both will, therefore, be in good condition and the drop off often seen at the edge of traffic lanes will be eliminated.

(ii) guardrails will replace the guide posts and/or bollards located at structures and on curves. These will reduce the severity of road accidents;
(iii) road markings such as center and traffic lane edge lines;
(iv) regulatory, warning, and advisory signs at required locations;

(v) rumble strips at locations where there is an additional need to warn drivers of the need to slow down, as well as traffic calming devises such as speed-humps and pedestrian crossings in towns; and

(vi) improved traffic flow control at intersections, such as medians and widening for turning traffic.

D. Road Side Services and Other Facilities

1. Service to be Relocated

106. Road side surveys of services located close to the road indicate that some services will need to be relocated, as follows:

a. Underground Cable Near Bridges

107. The fiber optic communication cable will need to be relocated at 12 structures (Table IV-1). At bridges, the cable will need to be relocated for a distance of 150 m from each end of the bridge. The new location for the cable should be at least 9 m from the road pavement edge, at the bridge abutments.

Table IV-1: Bridges Where Cable is to be Relocated

Location (Km)	Bridge Name	Structure Type	Bridge Length (ft)	Bridge Width (ft)
3.60	Kha Naung	Concrete Bridge	10	28
6.00	Pa Kout Yoe	Concrete Bridge	15	28
10.00	Lat Tat Gyi Yoe	Concrete Bridge	15	28
12.60	Htein Pin Yoe	Concrete Bridge	10	28
17.01	Lata Gyi	Concrete Bridge	20	28
26.21	Oo Yin Chaung	Bailey/to be replaced	300	12
29.41	Kyee Chaung	Concrete Bridge	28	14
32.20	Hlal Sate (Cable can be within 4 m of centerline south of the bridge.)	Concrete Bridge	90	24
37.81	Kha Naung	Concrete Bridge	100	28
49.01	Thaleik Kyee	Concrete Bridge	180	28
50.02	Thaleik Kalay	Concrete Bridge	100	28
53.20	Zchaung Twin (Cable location south of the bridge does not need to be moved)	Concrete Bridge	236	28
33.70	Kyaiklat Township Bridge (possible additional location)	Concrete Bridge	50	14

ft = feet, km = kilometer, m = meter.
Source: Prepared by the Consultant based on data provided by PW and MPT.

b. Relocation of other Services

108. Electrical and some telecommunication cables will need to be moved at the locations shown in Table IV-2.

Table IV-2: Services that Need to be Relocated

Location	Description	Comment
Km 0 (many sides)	Project road starts at a T-Intersection (Maubin Street). The power lines along both sides of the street will need to be relocated: • North side of street: relocate electricity 2 poles; move north by 10 m; • South side of street and both sides of the project road: relocate one pole on each side of the project road; move the 2 pole away from the centerline by 10 m	Road centerline will remain unchanged at Km 0 but be moved by 1 m to the left at km 0.3
Km 0 to 0.2 (left side)	Power line located on the right (west) edge of the road formation: move the electricity line	Road centerline will remain unchanged at Km 0 but will be moved by 1 m to the left at km 0.3
Km 8.2 (right side)	Curve radius will be increased: 1 electricity pole and 2 telecommunication poles need to be moved. Move the electricity pole by 15 m away from the existing road centerline and move the telecommunication poles by 10 m away from the existing road centerline.	Centerline will move to the left (larger radius)
Km 8.60 to Km19.90 (right side)	Power line would be located within the lower part of the road embankment batter. It needs to be moved by at least 7 m to the right (west side).	The road is to be moved to the right by 3.5 m from Km 8.7 to Km 24.0.
Km 31.6 to Km 32.0 (left side)	Power line needs to be moved by 5 m to the left (away from the road centerline); it needs to be 9 m minimum from the existing road centerline	
Km 41.6 to Km 42.0 (right side)	Relocate power line off the road embankment, 3 m to the right of the toe of embankment	Road centerline will be moved 1 m to the right
Km 42.6 to Km 43.0 (right side)	Relocate power line off the road embankment, 3 m to the right of the toe of embankment	Road centerline will be moved 1 m to the right
Km 48.8 Thaleik Kyee Bridge (left side)	Move MPT cable support towers to the left by 5 m	Road centerline will be moved 1 m to the right
Km 49.8 Thaleik Kalay Bridge (left side)	Move MPT cable support towers to the left by 5 m	Road centerline will be moved 1 m to the right
Km 52.1 to Km 52.7 (right side)	Move poles 5 m to the right (away from the existing road centerline	Road centerline will be moved 1 m to the right

km = kilometer, m = meter, MPT = Ministry of Post and Telecommunications.

2. Feature that will control road level in Kyaiklat and Phyapon

109. The road passes through 2 urban road sections. The level of the new road will be controlled by the following:

(i) 15 cross drains with removal covers at the same level as the existing road in Kyaiklat;
(ii) 75 mm water lines at 7 locations in Kyaiklat at a depth of 400 mm to 500 mm;
(iii) 23 cross streets within Kyaiklat;
(iv) 150 mm pipes across road at approximately Km 53.5 (in Phyapon); and
(v) Cross streets in Phyapon.

E. Bridges and Drainage

110. The proposed bridge and drainage works include bridge widening, upgrading of one

bridge, and minor corrective works on the structures and their approaches. Appendix H includes details of the various structures and the proposed improvements.

1. **Oo Yin Chaung Bridge**

111. The Oo Yin Chaung upgrading and superstructure design was carried out by the PW Bridge Department. The design load standard for the bridge is AASHTO HS-25. The works to be carried out on this bridge include the following:

(i) construction of a temporary bridge adjacent to the existing structure;
(ii) removal of the existing Bailey bridge and transporting to it to the PW Bridge Construction Unit compound at Bogale;
(iii) additional piling for the bridge abutments;
(iv) widening of the 2 abutments to accommodate a 2 lane superstructure with pedestrian walkways;
(v) new superstructure and road surfacing; and
(vi) improved road approach vertical alignment.

2. **Kyee Chaung Bridge**

112. This bridge is to be replaced with a 2 lane concrete structure that is 13 m long. It is to be constructed on the same centerline. A by-pass will need to be constructed and the existing bridge removed before this can be carried out.

3. **Kyaiklat Township Bridge**

113. It was reconstructed in mid-2013. Bridge widening was proposed just prior to the preparation of this report. Load carrying capacity of the existing structure has yet to be confirmed.

4. **Other drainage structures**

114. Extending three 0.9 m diameter pipe culverts. Works to be carried out will include:

(i) demolition of one existing headwall;
(ii) excavation of the foundation for the culvert, concrete bedding and pipe installation;
(iii) localized placement and compaction of backfill material; and
(iv) construction of new head walls.
Note: The condition of the culvert pipes and their alignment could not be established because the culverts were below water. This should be done during the dry season and any additional work assessed.

F. Pavement Thickness Design

a. General

115. The adopted design CBR for the project road embankment is 5% (after 4 days of soaking). The CBR 5% materials are both imported and modified (lime) local material that are 400 mm thick over the local fill material that has a soaked CBR of 1 to 2%.

b. Proposed Road Construction Materials

116. Materials available for constructing the road include:

(i) **Existing embankment.** silty clay soils with a 4 day soaked CBR of 2 to 3%;

(ii) **Road Fill.** silty sand material that is dredged from the river at a number of locations along the road, by commercial suppliers. As this material is likely to erode, the batter surface will be clad with the local silty clay soils;

(iii) **Improved Fill Layer.** silty sand and local silty clay soils stabilized with lime (2% to 2.5%) to produce at least a 5% CBR (4 day soaked) layer at the top of the road fill;

(iv) **Subgrade.** silty sand/silty clay blend (75:25) with a 4 day soaked CBR of at least 5%;

(v) **Subbase.** river gravel (shingles) dredged from the river and blended with sand and soil to produce a 4 day soaked CBR of 30%. Alternatives include stabilizing a blended silty sand and soil material, lateritic gravel that are reported to be available within 50 km of Phyapon, and also weathered rock;

(vi) **Recycled pavement.** the existing pavement consists of water bound and semi grout macadam that is approximately 250 mm thick and 5.5 mm–6.6 m wide. This will be salvaged, crushed or otherwise processed, and incorporated in the subbase layer;

(vii) **Base.** will be a dense graded crushed rock material that is a blend of commercially available crushed rock chippings (sized from crusher dust to 20 mm) that are mostly sourced from hard rock quarries in the Pyay and Mandalay areas;

(viii) **Surfacing aggregates.** available from the same sources as the base, indicated above. Los Angeles Abrasion test indicate that aggregate is of the right quality. Flakiness could, however, be an issue.

(ix) **Rigid pavements.** concrete will be 30 megapascals fast setting concrete. Aggregate will be sourced from the same sources as for surfacing aggregate.

c. Proposed Pavement Thickness

1. Flexible Pavement

117. The Transport Research Laboratory (TRL) Road Note (RN) 31 design manual has been adopted in Myanmar. The indicated pavement thicknesses, based on RN 31, are shown in Table IV-3 for a conventional flexible pavement and for a range of traffic loadings and 3 different design periods. The designs were also checked using the AASHTO design method. Only small differences in the pavement designs that resulted from applying both methods were noted.

118. Table IV-3 also shows the pavement thickness if an asphalt concrete surfacing, as favored by the MOC, is used.

119. It is proposed that the 20 year design life, assuming vehicle overloading, be adopted for the project.

120. The incorporation of some more sophisticated pavement layers (e.g. a stabilized subbase layer) would reduce the base and overall thickness. This would have required more investigation, and material testing and identification of the most likely materials to be stabilized. This was not possible during this short study. This could, however, be explored during construction.

Table IV-3: Flexible Pavement Thickness

	ESAL					
	0.7–1.5 million	**1.5–3.0 million**	**1.5–3.0 million**	**3.0–6.0 million**	**3.0–6.0 million**	**6.0–10.0 million**
Pavement layer	**10 year legal**	**10 year; 15% overloaded**	**15 year legal**	**15 year; 15% overloaded**	**20 year legal**	**20 year; 15% overloaded**
Surfacing	50 mm AC	50 mm AC	50 mm AC	50 mm AC	50 mm AC	50 mm AC
Base Thickness (mm)	175	175	175	175	175	200
Lime/sand/soil, or cement/sand/soil, or shingle/sand/soil blend	250	300	300	350	350	350
Subgrade and improved fill (CBR 5 minimum)	400	400	400	400	400	400
Total including imported fill (mm)	925	925	925	975	975	1,000

AC = asphalt concrete, CBR = California bearing ration, ESAL = equivalent single axle load, mm = millimeter.
Source: Prepared by Consultant

2. Rigid Pavement

121. Rigid pavements are proposed for the road sections through Kyaiklat and Phyapon. They have been proposed because side roads and existing road side services and development limit the both the width and height of the road. Existing cross drains with removable panels also mean that the concrete road segments will need to be constructed between the drains with provision made for expansion and/or contraction joints at these locations.

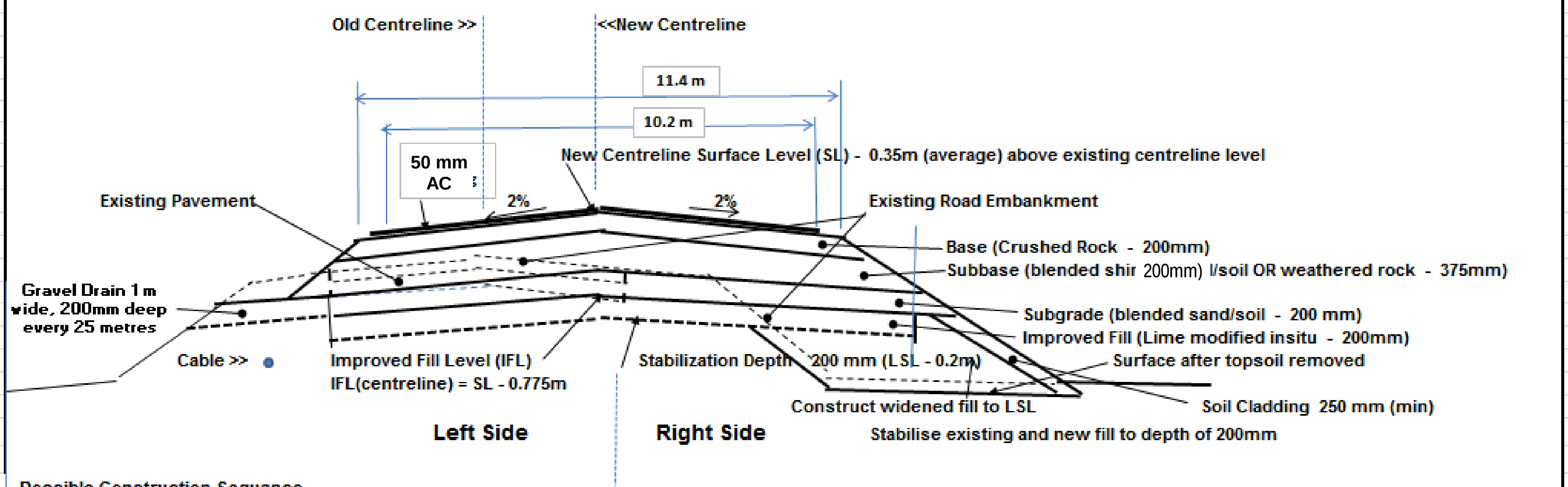
122. The assumed subgrade CBR for the concrete pavement sections was 3%. The resulting concrete pavement thickness, assuming 200 mm of an un-stabilized granular subbase and unsupported pavement edge[12] was 230mm. The design method used was the AASHTO method for rigid pavements.

123. The pavement thickness adopted for the project road is 250 mm, however, as a key way is proposed for the longitudinal joints instead of dowels, because of the possibility disturbance of dowels by passing traffic.

124. Transverse construction joints will have dowels at 280 mm spacing, placed at mid depth. Each dowel will be 32 mm in diameter x 0.45 m long. There will be saw cuts in the slab at 4.3 m to 4.5. m spacing. All transverse and longitudinal joints will be sealed with an appropriate sealant.

[12] Unsupported edge means that there is no kerb of adjoining concrete slab to carry some of the load.

Figure IV-1: Typical Cross Section where new Alignment has been offset by approximately 3 m and existing formation is narrow



Possible Construction Sequance

1 Close Right side to traffic, remove top soil, compact foundation, construct fill to top of the imporcved fill, lime stabilize to depth of 200mm and place the Subgrade layer

2 Close Left side to traffic, salvage pavement, excavate to IFL, lime stabilise to depth of 200 mm and place sand/soil subgrade to IFL + 200mm

3 Place subbase in half widths, closing one half to traffic.

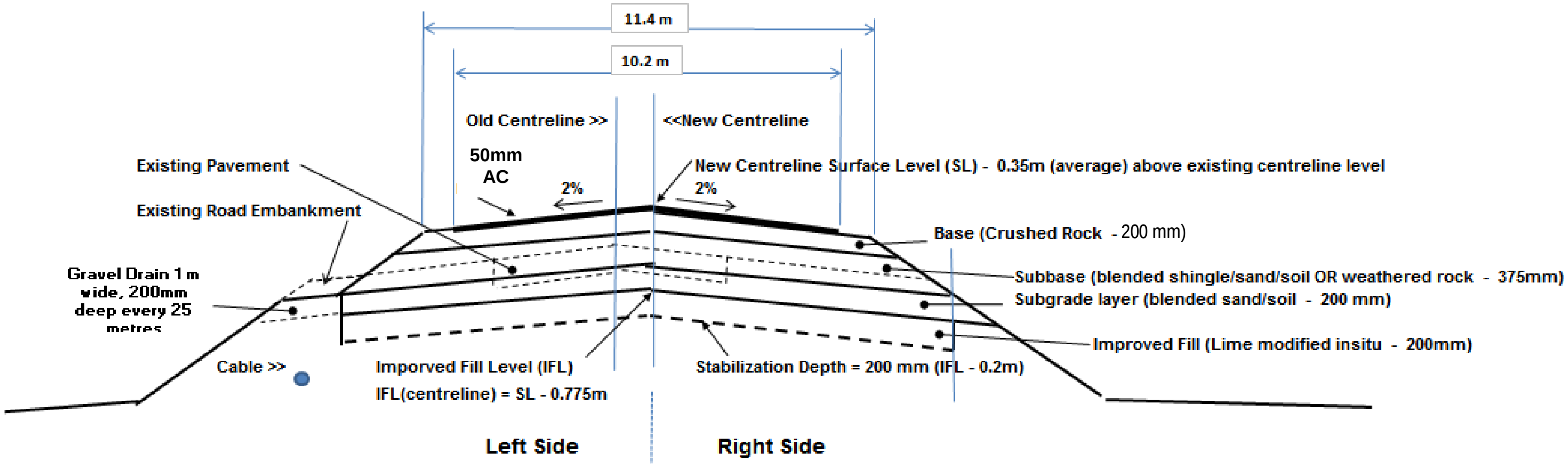
4 Place base in half widths, closing one half to traffic.

5 Apply prime coat and DBST seal
Asphalt Concrete Seal

Widened Existing Cross Section - Communication cable on left (East) side

Note: If communication cable is right of the existing centreline the widening is on the left

Figure IV-2: Typical Cross Section where New Alignment has been offset by 0 to 1 m and existing formation is wider



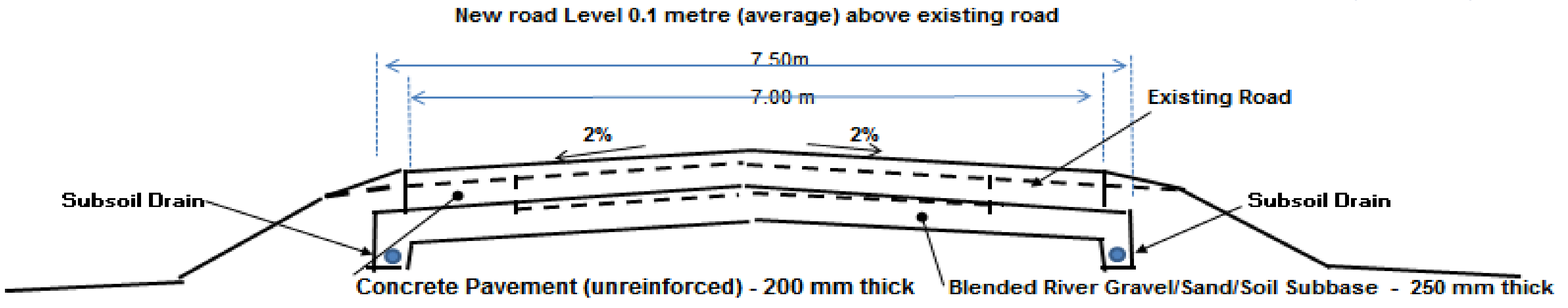
<u>Possible Construction Sequance</u>

1 Close Right side to traffic, remove top soil, compact foundation, construct fill to top of Improved Fill, lime stabilize to depth of 200mm and place the Subgrade layer
2 Close Left side to traffic, salvage pavement, excavate to IFL, lime stabilise to depth of 200 mm and place sand/soil subgrade to IFL + 200mm
3 Place subbase in half widths, closing one half to traffic.
4 Place base in half widths, closing one half to traffic.
5 Apply prime coat and Asphalt Concrete Seal

Widened Existing Cross Section - Communication cable on left (East) side

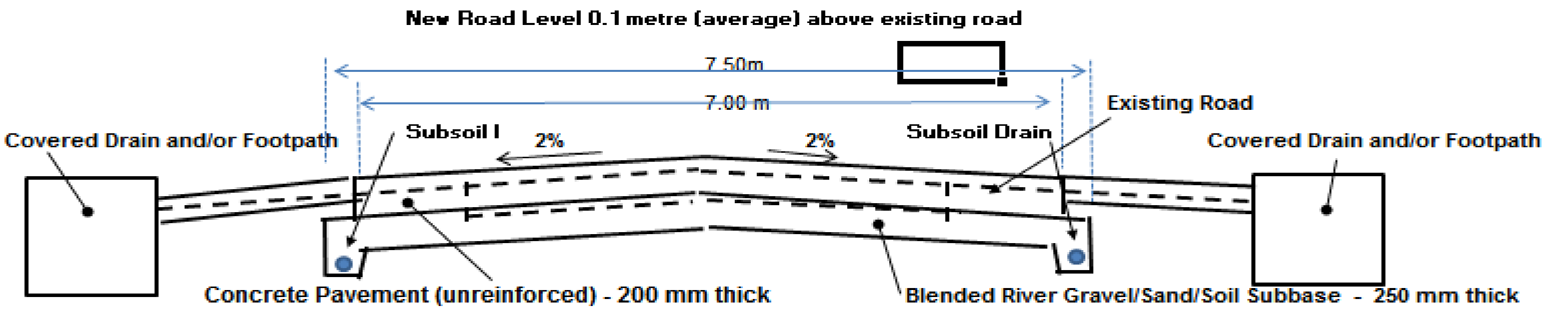
Note: If communication cable is right of the existing centreline the widening is on the left

Figure IV-3: Typical Cross Section



Note: Discharge subsoil drains through embankment or into the transverse drains that cross the road

Concrete Road Section - No Kerb Road Section



Note: Discharge subsoil drains through embankment or into the transverse drains that cross the road

Concrete Road Section - Existing Kerb Section

V. ENGINEERING PROPOSALS AND RECOMMENDATIONS

A. General

125. The engineering challenges referred to earlier include the conditions normally found in a delta area, namely weak soils, wet conditions, and the lack of good construction materials. The engineering solutions and initiatives incorporated into the pavement design, to deal with and address these issues, are discussed below.

B. Engineering Initiatives

a. Pavement Profile

i. Flexible Pavement (Whole road except urban sections)

126. The key features are:

(i) sealed shoulders to prevent rain water and surface runoff entering the pavement through the shoulder;
(ii) full width pavement construction – base and subbase pavement extends from batter to batter. This allows the water that enters the pavement to drain away;
(iii) a stabilized select fill layer that will act as a water table and capillary rise barrier; and
(iv) locally available materials used in the improved fill and key components in the subbase layer.

ii. Concrete pavements

127. Concrete has been specified in the urban areas because available road side development limits pavement height. This also controls road alignment and width of pavement.

128. While subsoil drainage is proposed, it will only be effective if the outlets are above the inverts of existing drains and the natural surface. Use of these drains will need to be reassessed in some locations as appropriate outlets will not always be available.

b. Pavement Materials

i. General

129. Blending materials to produce a subbase or base is not unusual in Myanmar and there are indications that stabilized materials have also been considered in the past. Blending crushed rock chippings of different sizes to produce a dense graded mix, to use as a subbase or base has apparently not been considered. Double bituminous surface treatment (DBST) seals, while used in the past, have not worked well, which is not surprising when the equipment and methods used are described.

130. The project, while not introducing completely new pavement layer materials will, nevertheless, introduce new methods that will produce higher quality materials and high quality construction pavements and surfacing. The methods will include a combination of in-situ and offsite operations as follows:

(i) <u>subbase</u> can be produced off-site or mixed in-place, using a blend of materials;

(ii) base course, consisting of crushed rock fractions, is better mixed off site, typically at the quarry where the crushed material is sourced; and

(iii) commercially available sealing chips will need to be screened to produce the single sized chips required for asphalt concrete.

ii. Crushed Rock Base

131. The proposed pavement will include a crushed rock base that will use the same material that is presently used in macadam construction, except that the material will be smaller and will consist of various size fractions to produce a dense graded mix. The proportion of each size fraction will need to be determined in a laboratory after material sources have been identified.

132. The required target grading for base materials is set out in Table V-1. The material should have a liquid limit of less than 35%, a plasticity index of less than 6%, a CBR greater than 80%, and a Los Angeles Abrasion value of less than 50%.

Table V-1: Crushed Rock Base Course Grading Requirements

Sieve Designation		Mass percent Passing	
Metric (mm)	**Imperial Units**	**Grading A**	**Grading B**
37.5	11/2 “	100	
25.0	1"	-	100
19.0	3/4"	60 – 85	-
12.5	½"	-	60 – 90
4.75	No. 4	30 – 55	35 – 65
0.425	No. 40	8 – 25	10 – 30
0.075	No. 200	2 – 14	5 -15

mm = millimeter.
Source: Transport Research laboratory (UK) - Road Note 31

iii. Subbase

133. The subbase layer can be a crushed rock blend, weathered rock or a mixture of river shingles, sand and some soil. The grading requirements are less demanding than required for a base course. The target grading is set out in Table V-2. The material should have a liquid limit of less than 35%, a plasticity index of less than 6%, a CBR greater than 30%, and a Los Angeles Abrasion value of less than 50%.

Table V-2: Subbase Grading Requirements

Sieve Designation		
Metric (mm)	**Imperial Units**	**Mass Percent Passing**
50.0	2"	100
25.0	1"	55 – 85
9.5	3/8"	40 – 75
0.075	No. 200	0 – 12

mm = millimeter.
Source: Transport Research laboratory (UK) - Road Note 31

iv. Improved Fill

134. The improved fill layer is the upper 200 mm of the road embankment fill that will be improved by stabilizing with lime. The road embankment fill will be made up of silty clay (the existing embankment) and the widened embankment, constructed using silty sand. Once the embankment fill (compacted as specified) is at the specified level (0.775 m below the

adopted final surface level), the top 200 mm will be scarified and stabilized with lime using in-place stabilizing equipment.

v. Subgrade

135. The subgrade will be a blended silty clay/silty sand mix as indicated above. This material could be blended off site or on site. The latter could be done with a grader or the in-place stabilizer. The only thing new for Myanmar would be the use of the in-place stabilizing equipment.

vi. DBST

136. For earlier DBST paved roads in Myanmar, inadequate equipment and poor work methods have led to seals that have started to lose aggregate within days. The reasons for this are well known and are easily solved.

137. While the sealing method itself is not unknown in Myanmar, the equipment and improved design, improved work methods, and quality control will certainly be new. Given that these types of seal are often the key to preserving a road network at low cost, as well as surfacing new roads, it is important that PW and the road construction industry learn how to seal roads well.

vii. Asphalt Concrete

138. Asphalt concrete surfaces are favored by MOC because of past improved performance and have, therefore, been considered as an option.

139. During the study, it was noted that recently placed asphalt concrete surfacing is below that which should be expected, suggesting that there are quality issues. With the involvement of international contractors and supervision consultants, however, there should be a significant improvement in the quality of asphalt concrete seals, as would be the case with DBST seals.

140. There will also be issues in areas where traffic is slow moving (toll stations, bridge approaches, bus stops, etc.).

141. The key concern with the use of a 50 mm asphalt concrete surfacing on the project road is the road embankment will consist of the existing and new embankment placed over soils that may be difficult to compact.[13] Differential settlement is, therefore, likely even though every effort will be made to minimize this by staging the construction and giving the widened portion of the road some time to consolidate before the final pavement layers are constructed. This applies especially to the northern 25 km and less to the remainder of the road.

142. Asphalt concrete pavements are less tolerant of movement and depressions and are likely to crack. Given this situation, the better approach would be to initially apply a DBST and follow this a few years later with asphalt concrete surfacing, if still required, after the road embankment has stabilized.

[13] Soils may be too wet or even covered with water.

VI. SPECIFICATIONS AND DRAWINGS

A. Overview

143. The short duration of this project preparatory study appeared to stretch PW resources and also required a revision of their various work programs. The resulting delays in the completion of topographic surveys and bridge designs has had a flow on effect, with the specification, drawings and BOQ not being completed at the time of writing this report.

144. The short duration of the project has also meant that it was only possible to do limited field investigations and surveys. This means that the CSC will be required to finalize some of the design. This is discussed below.

1. Specification and BOQ

145. The specification to be adopted for the proposed project road is one that has been extensively used in South East Asia. It has been adopted and expanded where required to conform to standards and specifications already used in Myanmar. Fortunately, these standards fit in well with those being proposed.

146. The specification makes reference primarily to AASHTO standards throughout the document and in some instances to British Standards. This is in keeping with the direction that PW wants to develop its road standards.

147. It is expected that the specification will be ready as a draft document by mid to late December 2013.

a. Drawings

148. Drawings had proceeded as far as was possible at the time of writing this report, except for the minor adjustments that are normally made when the full set of drawings has been prepared.

B. Design in Construction Phase

149. The CSC will be required to:

(i) review the pavement thickness design after a more detailed program of subgrade investigations and borrow material testing. Subgrade samples should be taken at 0.5 km intervals. Adjustments to the design should be made and the contractors instructed accordingly, within the confines of the contracts that will already by then exist, to the extent possible;
(ii) finalize the vertical alignment for the road, following a detailed survey of the road. The adopted design should raise the existing road level by an average of 0.35 m. Once established, the levels for the subgrade and other pavement layers can be determined (for example, the top of the improved fill is 0.75 m below the final surface level) and the limits of construction established after the new centerline location has been confirmed;
(iii) review the proposed centerline alignment shift following a more detailed investigation of the location of underground communication cable. Special attention should be given to the locations where the cable crosses the road, and at bridges where MPT has agreed to relocate the cable. Adjustments to the alignment shift, indicated in the drawings, should be made and the contractor instructed accordingly;

(iv) inspect the 3 pipe culverts located at Km 1.63, Km 3.38, and Km 7.25. These were underwater at the time of the study and could not be inspected. The condition of the culvert pipe and headwalls should be assessed and corrective works identified, designed, and work instructions issued to the contractor. Although a PC item will be included for this work, payment will be based on the work quantities and unit rates in the BOQ;

develop detailed solutions for correcting the poor vertical alignment on the approach to Oo Yin Chaung (Km 26.2) and bridges south of Km 29.5. Appendix H identifies possible solutions, which include the raising of abutment return walls and constructing low retaining walls as extensions to the abutment return walls to retain the raised embankment and also a widening of the embankment, as required. As the bridge abutment and kerb arrangements are different on each bridge, it will be necessary to develop a slightly different arrangement for each bridge. The vertical alignment solution should take account of the guardrails to be erected on the approach to each bridge and include the guardrail connection to the bridge structure in the developed solution. Appendix H also requires that the ends of kerbs and handrails are made safer. The consultant will need to develop a solution for each location that will be provided with guardrail. Once developed, the requirements should be documented and communicated to the contractor. It is expected that the development of the vertical solution would follow the detailed survey of the road. Although a PC item will be included for this work, payment will be based on the work quantities and unit rates in the BOQ; and

(v) develop details for raising and lengthening the headwalls at the 3 slab bridges, if required.

C. Lack of Familiarity with International Specifications

150. The specifications used in Myanmar, while relatively simple and short, do address the key specification requirements. While this is appropriate for “in house” operations and road works, they are not suitable for use in a more commercial sense where the specifications need to cover all types of situations and are therefore very extensive. PW staff will most likely find the specifications unfamiliar at first, and are likely to require assistance in understand the details of them. This assistance could be provided during the procurement process through the extension of the services of the present project procurement specialist, and is one of the key responsibilities of the CSC who could be required to conduct appropriate formal and “on the job” training.

VII. COST ESTIMATE

A. General

151. The lack of data on road works carried out by the private sector means that unit rates for the project works have been developed partly from first principles, using current material costs, equipment, and/or manpower hire rates. The calculations were carried out by engineers from one of the PW Special Construction Units and the study consultant.

152. A review of cost estimates prepared by local consultants and contractors showed that the PW "Analysis of Unit Rates" was being used to prepare estimates and tendered rates for private sector clients. The review of these rates showed up a weakness in the understanding of costs and estimating by the private sector with exceptionally high rates and also low rates being reported.

B. Key Unit Rates

153. The unit rates developed for the key items of work are summarized in Table VII-1.

Table VII-1: Key Works, Material and Equipment Unit Rates

Item	Description	Unit	Unit Rate ($)
Clearing and grubbing		m^2	0.3
Common Fill – Existing Embankment - (CBR 2 min.)	Silty Clay (cut to Fill)	m^3	3.0
Imported Fill	Silty Sand (sourced from River)	m^3	13.0
Improved Bill (CBR 5%)	Lime modifying local soil and silty sand	m^3	16.0
Subgrade (CBR 5 minimum)	Soil/sand blend	m^3	18.0
Recycle Existing pavement	Penetration and water bound macadam	m^3	25.0
Subbase	Shingle/soil	m^3	44.0
Base	Crushed Rock (dense graded)	m^3	102.0
Primer		m^2	1.0
Water Bound Macadam		m^3	115.0
Penetration Macadam (75mm)		m^2	14.7
Asphalt Concrete (50mm)		m^2	18.5
Concrete pavement	Fast Setting – including dowels, keyways, joints, etc.?	m^3	230.0
Miscellaneous Concrete		m^3	190.0
Line marking	Thermoplastic	m^2	25.0

CBR = California bearing ratio, m^2 = square meter, m^3 = cubic meter, mm = millimeter.
Source: Prepared by the Consultant.

C. Cost By Road Section

154. The resulting costs for each road section are in Table VII-2. Detailed BOQ will be prepared for the final report after road and bridge data and designs have been completed.

Table VII-2: Project and Road Section Costs (US$ million)

Surfacing Options	Road	Mobilize and Service Relocation	Bridges	Taxes	Total	$/km
Asphalt Concrete	44.3	1.6	2.2	2.4	51.4	923,965
Asphalt concrete (25 km)[1]	41.45	1.6	2.2	2.3	48.1	869,255

km = kilometer.
Source: Prepared by the Consultant

[1] The 25 km of asphalt concrete would be on the southern section of the road where the widening is negligible and likely differential settlement minimal.

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VIII. ROAD MAINTENANCE

A. General

155. The fact that Myanmar needs a large road works program is well understood and this will be addressed through projects that will bring the road network back to a maintainable state over time. Parts of the existing road network are, however, in average to good condition and the length of the network, in this condition, will increase over the years. Equally, the roads presently in average to good condition will deteriorate and will need to be rehabilitated in the next 5 to 7 years unless the rate of deterioration is slowed down. To do this, the PW will need to adopt a preservation philosophy whose aim is to extend the life of pavements and delay the need for rehabilitation and reconstruction.

156. A typical road manager, like PW, has a road network development and improvement responsibility, and a road asset preservation and maintenance responsibility. As the need to maintain the value of the existing investment in roads is as important as upgrading the road network, there is always competition between these two key areas of management responsibility.

B. Road Network Preservation

157. The road management strategy adopted by PW should include a preventive maintenance philosophy and program that focuses on the roads that will benefit from low cost treatments to extend pavement life.

158. PW will need to rethink its way of taking care of its various assets and become proactive rather than just reacting (repairing) to problems. This will require a better understanding of road management and the types of strategies, systems, and treatments required to manage the investment made by the country, in the road network, which is sizable. The PW network, if constructed today, would be worth more than $ 10 billion. At its present condition, it is worth perhaps $ 3 billion–$ 4 billion.

159. While it is not possible to retain the full “as built” value of the network because roads lose value and/or condition almost as soon as they have been constructed, it is possible to ensure that networks retain 75% to 80% of the “as new” value, by acting early, using low cost treatments rather than waiting for a problem to become serious.

160. The designs adopted for the project road include important elements of such a preventive maintenance strategy, as follows:

(i) a longer design life – 20 years instead of 10 years;
(ii) a pavement structure that will allow the water that enters the pavement structure to drain away;
(iii) sealed shoulders that ensure water does not “wet up” the pavement under the traffic lanes;
(iv) a stabilized layer to reduce the effects of a high water table; and
(v) a pavement type (dense graded crushed rock) that can be easily recycled in place through the addition of a cement or lime, and give the pavement a further 10 to 15 years of life.

C. Road Maintenance

161. The proposed additional role for the PW, namely that of preserving the investment made in road infrastructure, will require an adjustment in the way needed works are

identified, planned, and funded, as delays in doing needed works will mean that more expensive treatments will be required.

162. The preventive maintenance program will run in parallel with current repair and rehabilitation program for many years and this will mean competition for funds. Developing a good understanding of roads and how they react to traffic and environmental conditions is essential to understanding the consequence of the decisions to be made, when deciding how to allocate available funds. This understanding will be enhanced by the more frequent inspections required for preventative maintenance.

163. Little will happen, however, if the available treatments, work techniques, and quality control are limited. The above actions will need to be accompanied by developments in engineering and maintenance management and operations. This would require action and/or skills development in a number of areas, as follows:

1. **At Public Works (Repair and Maintenance Department)**

   (i) expanding the role of the department to encompass road network preservation;
   (ii) understanding the role of maintenance and preservation in maximizing pavement performance;
   (iii) developing the skills to present road network management and preservation programs and requests for funding;
   (iv) developing pavement management strategies and maintenance techniques;
   (v) preparing guidelines for inspections, defect recognition, maintenance treatment selection, specifications, work methods and quality control; and
   (vi) developing performance standards.

2. **At the Regional and District level**

   (i) understanding the factors that impact pavement performance;
   (ii) identifying the early signs problems and possible solutions;
   (iii) developing capability in new treatments, techniques, and materials;
   (iv) carrying out defect identification inspections surveys;
   (v) developing improved maintenance methods and quality control;
   (vi) introducing safe work practices;
   (vii) improving maintenance delivery (could include outsourcing of specific tasks);
   (viii) improving traffic control at work sites;
   (ix) documenting works done and costing works through a system of monitoring – implementing a maintenance management system;
   (x) monitoring operational and road and/or pavement performance; and
   (xi) undertaking road accident assessments and identifying road related mitigation measures.

D. Road Maintenance and the Project Road

164. The analysis of past expenditure and discussions with PW indicate that there is a low level of expectation regarding road performance with the result that the road management strategy is one of construct, repair, and reconstruct rather than construct, maintain, and/or preserve, minor repairs and rehabilitation where the aim is to achieve a defined long pavement life.

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165. The proposed road works will improve the quality of the road between Maubin and Phyapon, and while this should mean good ride quality for at least 15 years (and only require rehabilitation after 25 years), this will only happen if PW has a good road maintenance strategy in place, that includes periodic maintenance and a preventive routine maintenance approach.

166. An asphalt concrete seal will need to be resealed after 8 to 11 years, depending on the quality of the bitumen. Failure to do this and other minor works, when required, will mean that the significant works may be necessary after 10 to 12 years. The periodic maintenance would include some minor repairs and a 10 mm or 12 mm aggregate sprayed seal that would cost around $ 30,000 per km. The cost would depend on whether a capability has been developed in sprayed seals.

167. The PW will also need to invest in a routine maintenance program that includes pavement and road side activities. The latter includes the cutting of grass (on the unpaved shoulders and batters) and ensuring that water can drain from the pavement surface, the clearing of culverts and drains and other road side vegetation, and repairs to road damaged road side structures and furniture. Pavement related tasks would include regular inspections of the pavement surface to identify the early signs of a defect, such as fine cracking and shallow depressions or breaks in the surface that should be treated within weeks and not months. In the wet season, such treatment should be carried out within days.

ROAD CONDITION SURVEY

PRELIMINARY ROAD CONDITION ASSESSMENT

Odometer (km)							Widths (ft)		Pavement Thickness			Existing Data (2003 and 2006)				
From	To	Estimated IRI (>)	% Fail	% Crack	Shape*	Comment	Pave-ment	Forma-tion	Bitumen Macadam	WBM Base	Sub-base	CBR (4 Day soak)	OMC	Soils Class	Density (Feb 2006)	M/C (Feb.)
0.0	1.2	8	10	NA	P				75	150	No data	3%	19 to 20%	CH	No data	No data
1.2	2.9	7	30	30	P		22	36	75	150						
2.9	4.4	7	30	50	P		22	36	75	150						
4.4	6.1	7	10	15	P		22	36	75	150						
6.1	6.3	7	25	30	P		22	36	75	150						
6.3	7.9	7	5	15	P		22	36	75	150						
7.9	9.0	7	30	20	P		22	36	75	150						
9.0	9.3	7	NA	NA	G	new o/l	22	36	75	150						
9.3	10.4	6	10	15	F		22	36	75	150						
10.4	11.5	6	30	30	P		22	36	75	150						
11.5	12.3	7	20	20	P		22	36	75	150						
12.3	13.0	8	30	30	P		22	36	75	150						
13.0	14.0	7	20	25	P		22	36	75	150		No data	No data	No data		
14.0	15.4	7	20	35	P		22	36	75	150						
15.4	16.4	6	10	10	F		22	36	75	150						
16.4	17.0	6	30	10	F		22	36	75	150						
17.0	18.9	5	15	10	F		22	36	75	150						
18.9	19.7	5	25	20	F		22	36	75	150						
19.7	21.9	7	35	30	P		22	36	75	150						
21.9	22.6	5	15	20	F		22	36	75	150						
22.6	23.1	7	30	30	P		22	36	75	150						
23.1	23.9	8	40	30	VP		22	36	75	150						
23.9	25.4	10	40	30	VP		22	36	75	150						
25.4	26.3	6	10	15	F		22	36	75	150						
26.3	28.0	8	55	50	VP		22	36	75	150						
28.0	32.1	7	45	45	VP		22	36	75	150						
32.1	32.8	10	50	50	VP	Start of Kyaiklat	18	24	No data	No data						
32.8	33.2	7	15	10	F		18	24								

Odometer (km)							Widths (ft)		Pavement Thickness			Existing Data (2003 and 2006)				
From	To	Estimated IRI (>)	% Fail	% Crack	Shape*	Comment	Pave-ment	Forma-tion	Bitumen Macadam	WBM Base	Sub-base	CBR (4 Day soak)	OMC	Soils Class	Density (Feb 2006)	M/C (Feb.)
33.2	34.1	12	50	50	VP		18	36	No data	No data	No data	No data	No data	No data	No data	No data
34.1	35.0	7	10	50	F		18	36								
35.0	35.2	12	50	50	VP	End of Kyaiklat	No data	No data								
35.2	35.7	7	20	45	F		18	36	75	150		3%	19 to 20%	CH	83 to 87%	10.5 to 12.5%
35.7	36.3	7	40	40	P		18	36	75	150						
36.3	36.8	8	30	35	P		18	36	75	150						
36.8	37.8	7	10	5	VP		18	36	75	150						
37.8	38.6	15	50	50	VP		18	36	75	150						
38.6	39.1	8	25	35	VP		18	36	75	150						
39.1	40.6	9	25	40	VP		18	36	75	150						
40.6	41.1	15	60	NA	VP		18	36	75	150						
41.1	42.1	8	30	50	VP		18	30	75	150						
42.1	44.0	12	40	50	VP		18	40	75	150		2%				
44.0	52.7	12	50	50	VP		18	40	75	150						

CBR = California bearing ratio, ft = feet, IRI = international roughness index, km = kilometer, OMC = optimum moisture content.

*Shape: VP = very poor, P = poor, F = fair, G = good.

GEOTECHNICAL INVESTIGATIONS AND MATERIAL TESTING

Geotechnical Investigation - Existing Road Formation

Note: Compaction Tests - Modified Compaction Test

Test Results on Existing Road formation

Location			Test Pit				DCP Measurements/CBR below bottom of Test Pit					
Location (Mile)	Location (km)	Offset (ft) from Centreline	Depth below Top Soil Layer	Field Moisture Content (%)	Field Dry Density (lb/ft3)	Relative Dry Density (%)	Depth (ft)	Blows	Penetration in mm	CBR (%)	Lab CBR(%)	Remarks
"6/4	10.4											Km 10.4 Soil
RHS		6	0 to 1	-	-		0 to 1	1	26.4	9.5		MDD = 107 lb/ft3
			1 to 2	23.6	99.1	94%	1 to 2	1	27	9.3		OMC- 13.0%
							2 to 3	1	21.6	11.7		PI = 50%; LS = 16.4%
												CBR (4day) = 3%
"12/5	20.2	6	0 to 1	-	-		0 to 1	1	23.7	10.6		CBR 7 day soak = 1%
LHS			1 to 2	23.2	97.3	93%	1 to 2	1	37.8	6.5		
							2 to 3	1	37.3	6.6		Km 10.4 Sand/Soil
												MDD = 131 lb/ft3
18/6	26.8		0 to 1	-	-		0 to 1	1	66	3.6		OMC- 6.6%
RHS		6	1 to 2	30.1	90.1	86%	1 to 2	1	27.7	9.0		PI = 18%
							2 to 3	1	15.8	16.3		CBR (4day) = 3%
20/4	32.8		0 to 1	-	-		0 to 1	1	35.1	7.0		
RHS		4	1 to 2	34.4	87.9	84%	1 to 2	1	11.8	22.2		Km 20.2 Soil
Kyaiklat							2 to 3	1	8.52	31.4		MDD = 107 lb/ft3
												OMC- 17%
22/1	35.4		0 to 1	-	-		0 to 1	1	13.5	19.3		PI = 37.4
LHS		4	1 to 2	22	100.8	93%	1 to 2	1	30	8.3		LS = 14.2%
Kyaiklat							2 to 3	1	14.9	17.4		CBR (4day) = 2%
24/5	39.4		0 to 1	-	-		0 to 1	1	39.4	6.2		
LHS		6	1 to 2	29.8	92.8	86%	1 to 2	1	15.3	16.9		Km 20.2 Sand/Soil
							2 to 3	1	10.9	24.2		MDD = 130lb/ft3
												OMC- 6%
27/1	10.4		0 to 1	-	-		0 to 1	1	35.1	7.0		PI = 13.8
RHS		6	1 to 2	31.7	91.1	84%	1 to 2	1	11.8	22.2		CBR (4day) = 5%
							2 to 3	1	8.52	31.4		CBR (7day) = 1%
29/5	43.4		0 to 1	-	-		0 to 1	1	33.6	7.4		Km 50.6 Soil
LHS		6	1 to 2	29.8	94.5	88%	1 to 2	1	14.7	17.6		MDD = 107 lb/ft3
							2 to 3	1	17.6	14.6		OMC- 9%
												PI = 13.8%
31/6	43.4		0 to 1	-	-		0 to 1	1	28.8	8.7		LS = 11%
RHS		6	1 to 2	24.8	101.8	94%	1 to 2	1	15.2	17.0		CBR (4day) = 5%
							2 to 3	1	10.2	25.9		CBR (7day) = 1%

Geotechnical Investigation - Sample from Beside Road

Note: Compaction Tests - Modified Compaction Test

Test Pits Beside the Road Embankment

Location			Test Pit				DCP Measurements/CBR below bottom of Test Pit					
Location (Mile)	Location (km)	Offset (ft) from Centreline	Depth below Top Soil Layer (ft)	Field Moisture Content (%)	Field Dry Density (lb/ft3)	Relative Dry Density	Depth (ft)	Blows	Penetration in mm	CBR (%)	Lab CBR(%)	Remarks
0/4	0.8											Km = 0.7
RHS		18	0 to 1	23	92.4	83%	0 to 1	1	83	2.8		MDD = 111 lb/ft3
			1 to 2	24.6	92.1	83%	1 to 2	1	40.7	6.0		OMC = 7%??
							2 to 3	1	26	9.6		PI = 32%
0/4	0.8	18	0 to 1	29.1	90.1	81%	0 to 1	1	182	1.2		CBR 4 Day soak = No Test
LHS			1 to 2	30.4	88.8	80%	1 to 2	1	48	5.0		
							2 to 3	1	14.5	17.9		
"5/4	8.8		0 to 1	27.3	91.8	83%	0 to 1	1	106	2.2		
RHS		18	1 to 2	28.2	90.8	82%	1 to 2	1	24	10.5		
							2 to 3	1	12.6	20.7		
"5/4	8.8		0 to 1	25.50	90.10	81%	0 to 1	1	169	1.3		
LHS		18	1 to 2	29.10	85.90	77%	1 to 2	1	370	0.6		
							2 to 3	1	54	4.5		
"10/4	16.8		0 to 1	28.40	89.60	81%	0 to 1	1	113	2.0		
RHS		18	1 to 2	26.10	92.90	84%	1 to 2	1	37	6.6		
							2 to 3	1	29	8.6		
"10/4	16.8		0 to 1	29.50	86.20	78%	0 to 1	1	106	2.2		
LHS		18	1 to 2	34.40	83.30	75%	1 to 2	1	32	7.7		
							2 to 3	1	16	16.1		Km = 13.2
												MDD = 119 lb/ft3
"15/4	24.8		0 to 1	34.50	82.00	79%	0 to 1	1	174	1.3		OMC =11. 7%
RHS		24	1 to 2	32.60	80.60	78%	1 to 2	1	52	4.6		PI = 31%
							2 to 3	1	22	11.5		
												CBR 4 day soak = 2%
"15/4	24.8		0 to 1	31.60	88.80	85%	0 to 1	1	146	1.6		
LHS		24	1 to 2	37.70	83.00	80%	1 to 2	1	27	9.3		
							2 to 3	1	13	20.1		
20/4	32.8		0 to 1	31.60	83.80	81%	0 to 1	1	115	2.0		
RHS		24	1 to 2	30.10	86.00	83%	1 to 2	1	29	8.6		
Kyaiklat							2 to 3	1	18	14.2		
20/4	32.8		0 to 1	32.50	81.50	78%	0 to 1	1	91	2.6		
LHS		24	1 to 2	38.00	78.60	76%	1 to 2	1	26	9.6		
Kyaiklat							2 to 3	1	17	15.1		
24/4	39.2		0 to 1	34.00	85.00	82%	0 to 1	1	80	2.9		Km = 24.5
RHS		24	1 to 2	34.40	87.00	84%	1 to 2	1	24	10.5		MDD = 104 lb/ft3
							2 to 3	1	11	23.9		OMC = 11.7%??
												PI = 43
24/4	39.2		0 to 1	32.30	87.60	84%	0 to 1	1	166	1.4		
LHS		24	1 to 2	31.40	87.80	84%	1 to 2	1	46	5.3		CBR 4 day soak = 3%
							2 to 3	1	14	18.6		CBR 7 day soak = 1%
30/3	48.6		0 to 1	30.90	90.60	87%	0 to 1	1	114	2.0		
RHS		24	1 to 2	37.00	84.30	81%	1 to 2	1	23	11.0		
							2 to 3	1	12	21.8		
30.3	48.6		0 to 1	36.30	83.70	80%	0 to 1	1	64	3.7		
LHS		24	1 to 2	34.70	80.50	77%	1 to 2	1	20	12.7		

Maubin - Kyeiklatt - Phyarpon Road

Soil Samples from Subgrade

SR	Location	Grading	Liquid	Plasticity	Linear	Compaction test		Soaked CBR	
NO.			Limit	Index	Shrinkage	OMC	MDD	4 days	7 days
			(%)	(%)	(%)	(%)	(lb/ft³)		
1	6/4 Granular Mix Existing	Â	37.0	18.1	10	6.6	131	6	3
2	6/4 Subgrade Soil Existing	Â	76.4	50.5	16.4	13.0	107.8	3	1
3	12/5 Granular Mix Existing	Â	31.0	13.8	6.4	6.0	130.7	5	1
4	12/5 Subgrade Soil Existing	Â	61.3	37.4	14.2	17.0	104.7	2	-
5	31/6 Subgrade Soil Existing	Â	36.0	13.8	11.4	9.0	106.6	2	-

Possible Filling Material

SR	Location	Grading	Liquid	Plasticity	Linear	Compaction test		Soaked CBR	
NO.			Limit	Index	Shrinkage	OMC	MDD	4 days	7 days
			(%)	(%)	(%)	(%)	(lb/ft³)		
1	Phyarpon Sand 1	Â	Non-	Plastic	-	5.2	108.2	8	8
2	Phyarpon Sand 2	Â	Non-	Plastic	-	8.2	106.8	4	4
3	Kyeiklatt Sand	Â	Non-	Plastic	-	8.4	107.2	5	5

Possible Subbase or Select Subgrade Material

SR	Location	Grading	Liquid	Plasticity	Linear	Compaction test		Soaked CBR	
NO.			Limit	Index	Shrinkage	OMC	MDD	4 days	7 days
			(%)	(%)	(%)	(%)	(lb/ft³)		
1	**12/3 Soil for Mix**	Â	42.4	20.65	10.71	13.6	104.8	1	-
2	**26/1 Soil for Mix**	Â	50.2	28.2	13.57	14.2	108	1	-
3	**12/3 Soil + Sand**	-	34.5	16.27	-	-	-	-	-
	75 : 25	-	34.5	16.27	-	-	-	-	-
4	50 : 50	-	25.5	11.68		8.2	124		
5	25 : 75	-	Non Plastic		-	8.2	118	7	6
6	30 : 70	-	Non Plastic		-	8.8	116.6	4	1
7	40 : 60	-	24.9	10.01	-	-	-	-	-
8	45 : 55	-	26.2	11.43	-	-	-	-	-
9	35 : 65	-	17.8	4.13	2.14	7.8	119.6	3	2
10	**26/1 Soil + Sand** 75 : 25	-	36.2	19.1	-	-	-	-	-
11	50 : 50	-	26.35	12.4	-	-	-	-	-
12	25 : 75	-	Non Plastic		-	11.1	116.5	5	3
13	30 : 70	-	Non Plastic		-	9.7	116.2	5	2
14	35 : 65	-	19.99	5.69	3.57	9.2	116.3	3	2
15	40 : 60	-	21.9	10.22	-	-	-	-	-
16	45 : 55	-	22.45	10.45	-	-	-	-	-

Specification - Liquid limit < 35 %
Plasticity Index < 6%
Linear Shrinkage < 3%

Road Side Soil (Embankment Soil)

SR	Location	Grading	Liquid	Plasticity	Linear	Compaction test		Soaked CBR	
NO.			Limit	Index	Shrinkage	OMC	MDD	4 days	7 days
			(%)	(%)	(%)	(%)	(lb/ft³)		
1	0/4 Soil	Â	59.7	32.15	15.71	7.3	111.4	3	-
2	15/4 Soil	Â	60.3	41.31	15.71	11.7	104.1	3	1
3	8/2 + 500' Soil	Â	56.6	30.75	14.2	13.3	119.0	2	-

Crushed Rock Test Results

GRADING OF BASE MATERIAL FOR ROAD

(Pyay - Ka Myaing Crushed Rock)

SIEVE SIZE	50mm	37.5mm	28mm	20mm	10mm	5mm	2.36mm	0.425mm	0.075mm	Pan
Wt of Retained (g)		1000	-	11000	8000	7000	4000	3800	1800	3400
Wt of Passing (g)	40000	39000	-	28000	20000	13000	9000	5200	3400	-
% Passing	100	97.5	-	70	50	32.5	22.5	13	8.5	-
% Retained		2.5	-	27.5	20	17.5	10	9.5	4.5	-

Loose Density = 118 lb/cu-ft

(Htone Bo (Mandalay) Crushed Rock)

SIEVE SIZE	50mm	37.5mm	28mm	20mm	10mm	5mm	2.36mm	0.425mm	0.075mm	Pan
Wt of Retained (g)		1000	-	11000	8000	7000	4000	3800	1800	3400
Wt of Passing (g)	40000	39000	-	28000	20000	13000	9000	5200	3400	-
% Passing	100	97.5	-	70	50	32.5	22.5	13	8.5	-
% Retained		2.5	-	27.5	20	17.5	10	9.5	4.5	-

Loose Density = 117 lb/cu-ft

(Pyay - Ka Myaing Crushed Rock)

SIEVE SIZE	50mm	37.5mm	20mm	5mm	1.18mm	0.3mm	0.075mm	Pan
Wt of Retained (g)		3500	3500	5250	6650	5775	5075	5250
Wt of Passing (g)	35000	31500	28000	22750	16100	10325	5250	-
% Passing	100	90	80	65	46	29.5	15	-
% Retained	-	10.0	10.0	15	20.0	16.5	14.5	-

Loose Density = 116.3 lb/cu-ft

(Htone Bo (Mandalay) Crushed Rock)

SIEVE SIZE	50mm	37.5mm	20mm	5mm	1.18mm	0.3mm	0.075mm	Pan
Wt of Retained (g)		3500	3500	5250	6650	5775	5075	5250
Wt of Passing (g)	35000	31500	28000	22750	16100	10325	5250	-
% Passing	100	90	80	65	46	29.5	15	-
% Retained	-	10.0	10.0	15	20.0	16.5	14.5	-

Loose Density = 115 lb/cu-ft

MILE 18/6 EXISTING CRUSHED ROCK

SIEVE SIZE	4"	3½"	2½" 63mm	1½" 37.5mm	3/4" 20mm	Pan
Wt of Retained (g)	19795	7928	6673	5972	4365	1563
Wt of Passing (g)	26501	18573	10900	5928	1563	
% Passing	57.24	40.12	23.54	12.80	3.4	

Total wt = 46296

PAVEMENT STABILISATION TEST RESULTS

10th/Oct/2013 JICA expert team

No	Material	C.B.R (%)	Specified CBR (%)	USC (Mpa)	Specified UCS (Mpa)	Consistency			O.M.C (%)	M.D.D (g/cm³)
						L.L(%)	P.L(%)	PI(%)		
For Capping Layer (For Sub-grade)										
1	Cl.Soil (CBR 3%)+ Lime 4 %	19	> 15			43.0	27.8	15.2	14.0	1.674
2	Cl.Soil (CBR 4%)+ Lime 4 %	20	> 15			39.0	25.1	13.9	13.0	1.690
3	SM Soil (CBR 6%)+ Lime 4 %	27	> 15			37.5	24.4	13.1	10.6	1.834
For Sub-base Course										
1	Cement 4% + Soil	40	>70			50.0	25.0	25.0	12.0	1.724
2	Cement 6% + Soil	50	>70			48.0	25.0	23.0	9.0	1.733
3	Soil + Sand 10% + Lime 4 %			0.6	0.75 - 1.5	34.8	24.0	10.8	12.0	1.740
4	Soil + Sand 10% + Lime 6%			0.72	0.75 - 1.5	32.0	23.3	8.7	11.9	1.733
5	Soil 70%+ Sand 30% + Lime 8%			0.69	0.75 - 1.5	34.0	23.0	11.0	14.7	1.751
6	Soil 70%+ Sand 30% + Lime 10%			0.65	0.75 - 1.5	35.0	24.0	11.0	13.2	1.725
7	Soil + C/R (30: 70) + Lime 4%			0.7	0.75 - 1.5				25.0	1.458
8	Soil + C/R (25: 75) + Lime 6%			0.9	0.75 - 1.5				11.6	1.724
9	Soil + C/R (30: 70) + Lime 6%			0.78	0.75 - 1.5				15.0	1.850
10	Soil + Sand 10% + Cement 4 %			0.76	0.75 - 1.5	32.0	21.0	11.0	11.6	1.828
11	Soil + Sand 10% + Cement 6 %			1.11	0.75 - 1.5	37.0	30.0	7.0	11.7	1.879
12	Soil 50% + Sand 50% + Cement 6%			1.4	0.75 - 1.5	26.0	20.0	6.6	10.5	1.816
13	Soil + C/R (25: 75) +Cement 4%			1.00	0.75 - 1.5				10.0	1.898
14	Soil + C/R (25: 75) +Cement 6%			1.25	0.75 - 1.5				13.0	1.818
15	Soil + C/R (25: 75) +Lime 4%	52.0			0.75 - 1.5					
16	Soil + C/R (30: 70) +Lime 6%	25.0			0.75 - 1.5					
17	Soil + C/R (25: 75) +Lime 10%	19.6			0.75 - 1.5					
For Road-base Course										
1	Soil + C/R (25 : 75) + Lime 8%			0.8	0.1.5 – 3.0				18.9	1.943
2	Soil + C/R (25 : 75) + Lime 10%			0.7	0.1.5 – 3.0				18.0	1.762
3	Soil 15% + Sand 15% + C/R (25 : 75) + Lime 10%			3.6	0.1.5 – 3.0				14.0	1.954
4	Soil 15% + Sand 15% + C/R (25 : 75) + Lime 10%			3.9	0.1.5 – 3.0				12.6	1.983

ROAD WORK NEEDS ASSESSMENT

1. Table below is a summary of the work needs inspection carried out in early September 2013.

2. The distances shown in column 1 are vehicle odometer reading that will be adjusted after the centerline survey has been completed.

PROJECT ROAD OBSERVATIONS AND PROPOSALS FOR DESIGN AND CONSTRUCTION

Road Section (km)*	Description	Proposed Road Design/Construction Action/Comment	Issues
0.0	T intersection with single lane road	It is proposed that the existing single lane road be widened to include a turning lane for a length of approximately 20 m and then transition to a single lane. *The single lane road embankment would be widened on the south side to accommodate the turning lane*	Power and (legal and illegal) will need to be relocated
At the start of the road 0.0 to 0.1	Project road is a single lane gravel road (water bound macadam) that is not centered on the road embankment	As road side conditions to the west of the road embankment are poorly drained and have standing water, it is proposed that the road centerline is moved to the east by 1 m at Km 0.0 and by 2 to 3 m at Km 0.2	Power line west of road will not to be relocated. Overhead communication cable 10 m to 12 m east of centerline is clear of the actual road works but within construction operating zone *Location of underground cable (if present) is not known at present*
0.3	Road is centered on embankment. Paddy fields start at the toe of the road embankment.	Centerline could be retained or moved to the east so widening is on one side only. Paddy at toe of road embankment means that there would need to be some stripping of organic material before starting embankment construction	Power line west of road needs be relocated for part of this section. Overhead communication cable 10 to 12 m east of centerline is clear of the actual road works but within construction operating zone
0.1 to 1.2	Road is centered on embankment. Paddy fields start at the toe of the road embankment.	Centre line could be retained or moved to the east so widening is on one side only. Paddy at toe of road embankment means that there would need to be some stripping of organic material before starting embankment construction *It is proposed that the road be constructed to a narrow 2 lane standard (5.5 m for traffic lanes and 2 m for each shoulder (sealed for 1.5 m)*	Power line west of road needs be relocated for part of this section. Overhead communication cable 10 to 12 m east of centerline is clear of the actual road works but within construction operating zone *Location of underground cable is not known at present*
1.2	Intersection with Maubin bypass road	Main traffic flow is from the bypass to the project road south of the intersection. The section between Km 0 and	Power line west of road needs be relocated for part of this section.

Road Section (km)*	Description	Proposed Road Design/Construction Action/Comment	Issues
		Km 1.2 is a minor road. The intersection design will make it clear that the road section north of the intersection is the lesser road (traffic island and minor alignment change will achieve this goal)	Overhead communication cable 10 to 12 m east of centerline is clear of the actual road works but within construction operating zone
1.2 to 3.1	Road is centered on embankment. Paddy fields start at the toe of the road embankment. 6 m pavement flanked by steeply (15% to 20%) sloping grassed shoulders that are 2 m (east) and 3 m (west) wide. Batter width is a further 3 m (east) and 2 m (west). Height of road is approximately 0.7 m.	Centre line should be retained with widening both sides unless existence of cable prevents widening on cable side. Then possibly move to the west by a few meters.	Overhead communication cable 10 to 12 m east of centerline is clear of the actual road works but within construction operating zone *Underground cable is within road embankment except at bridges where it is contained in an above ground concrete structure approximately 9 m to 10 m from the centerline*
4.8	Side road west side	Provide bus bay	
3.1 to 5.4	6 m pavement flanked by grassed shoulders that are 0.5 m wide (east and west). Steep sloping shoulder and batter are a further 5 to 6 m (east and west). Height of road is approximately 1 to 1.5 m	Keep centerline or move to the west to avoid underground cable	Overhead communication cable 10 m to 12 m east of centerline is clear of the actual road works but within construction operating zone
7.6	Side road west side	Possible bus stop and a short length of paving	
8.3 and 8.45	Rumble strips both ends of curve	Review curve radius and consider increasing radius	Overhead communication cable 10 m to 12 m east of centerline is clear of the actual road works but within construction operating zone. Power line is approximately 10 m west of centerline *Underground cable is within road*

Road Section (km)*	Description	Proposed Road Design/Construction Action/Comment	Issues
			embankment except at bridges where it is contained in an above ground concrete structure approximately 9 m to 10 m from the centerline
5.4 to 9	6 m pavement flanked by grassed shoulders that are 0.5 m wide (east and west). Steep sloping shoulder and batter are a further 5 m to7 m (east and west). Height of road is approximately 1 m.	*Keep centerline or move to the west (up to Km 8 and to the east after Km 8) to avoid underground cable*	Overhead communication cable 10 m to 12 m east of centerline is clear of the actual road works but within construction operating zone. Power line is approximately 10 m west of centerline
9 to 9.9	6 m pavement flanked by grassed shoulders that are 0.5 m wide (east and west). Steep sloping shoulder and batter are a further 5 m to7 m (east and west). Height of road is approximately 1 m.	Except that high decreases progressively to approximately 0.3 m	Overhead communication cable 10 m to 12 m east of centerline is clear of the actual road works but within construction operating zone. Power line is approximately 10 m west of centerline
11.8	6 m pavement flanked by grassed shoulders that are 0.5 m wide (east and west). Steep sloping shoulder and batter are a further 4 m to 5 m (east and west). Height of road is approximately 0.3 m	*Keep centerline or move (to west - up to Km 8 and to the east after Km 8) to avoid underground cable*	Overhead communication cable 10 m to 12 m east of centerline is clear of the actual road works but within construction operating zone. Power line is approximately 10 m west of centerline
9.9 to 11.8	Refer to Km 9 and Km 11.8 for cross section details	Keep centerline or move to the west to avoid underground cable Raise embankment by 0.3 m to 0.4 m	Service both sides - clarification being sought
11.8 to 12	Refer to Km 9 and Km 11.8 for cross section details	Keep centerline or move to the west to avoid underground cable Raise embankment by 0.3 m to 0.4 m	Service both sides - clarification being sought
12.0	6 m pavement. Steep sloping grassed shoulder	Keep centerline or move to the west to avoid underground cable	Service both sides - clarification being sought

Road Section (km)*	Description	Proposed Road Design/Construction Action/Comment	Issues
	and batter are a further 6 m to 7 m (east and west). Height of road is approximately 0.7 m.	Raise embankment by 0.2 m	
12 to 13.5	6 m pavement. Steep sloping grassed shoulder and batter are a further 6 m to 7 m (east and west). Height of road is approximately 0.7 m.	Raise up to 0.3 m. Cross section as for Km 12.0	Service both sides - clarification being sought Power pole 7 m from center line on curve (west)
13.5 to 15.5	6 m pavement. Steep sloping grassed shoulder and batter are a further 6 m to 7 m (east and west). Height of road is approximately 0.7 m.	Keep centerline or move to the west (confirm) to avoid underground cable	Service both sides - clarification being sought
16.9	Curve	Review curvature	Consider improving curve
15.5 to 18.6	6 m pavement. Steep sloping grassed shoulder and batter are a further 4 m to 5 m (east and west). Height of road is approximately 1.0 m	Keep centerline or move to the east to avoid underground cable	Service both sides - clarification being sought
18.6 to 21.6	6 m pavement. Steep sloping grassed shoulder and batter are a further 5 m to 6 m (east and west). Height of road is approximately 1.0 m	Keep centerline or move to the east to avoid underground cable	Service both sides - clarification being sought
19.4	Side roads (both sides)	Possible bus stop and a short length of paving (both sides)	Approximately 10 buildings in row
20.2	Canal (both sides)	Possible widening for freight transfer	
21.3	Concrete pit (LHS) in shoulder	Need to establish what it is. Possibly needs to be moved.	Power line 50 m west Overhead phone cable 12 m to 15 m east

Road Section (km)*	Description	Proposed Road Design/Construction Action/Comment	Issues
			Underground OFC (location to be confirmed)
21.6	Banana trees	Will need to be removes. Compensation	Power line 50 m west Overhead phone cable 12 m to 15 m east Underground OFC (location to be confirmed)
21.6 to 27.2	6 m pavement. Steep sloping grassed shoulder and batter are a further 5 m to 6 m (east and west). Height of road is approximately 1.0 m	Keep centerline or move to the east (confirm) to avoid underground cable	Power line 50 m west Overhead phone cable 12 m to 15 m east Underground OFC (location to be confirmed)
22.8	Road RHS	Possible bus stop and a short length of paving	Power line 50 m west O/h phone cable 12 m to 15 m east Underground OFC (location to be confirmed)
24.4	Track	Possible bus bay location (check)	Power line 50 m west O/h phone cable 12 m to 15 m east Underground OFC (location to be confirmed)
24.6	Road LHS (to pagoda)	Improve intersection	NA
27	Bridge	Improve approach alignment. Will require abutment return wall to be raised and a retain wall to be constructed for approximately 10 m both sides and both ends, as well as embankment widening. Detailed assessment is required	Telecom cables are attached to the bridge
28.7	Road (LHS)	Possible bus stop and a short length of paving	NA
29.3	Concrete pit (RHS) 8 m from centerline	Need to establish what it is. Possibly needs to be moved.	Power line 50 m west O/h phone cable 12 m to 15 m east Underground OFC (location to be confirmed)
27.2 to 33.0	6 m pavement. Steep sloping grassed shoulder	Keep centerline or move to the west (confirm) to avoid underground cable	Service both sides - clarification being sought

Road Section (km)*	**Description**	**Proposed Road Design/Construction Action/Comment**	**Issues**
	and batter are a further 6 m to 7 m (east and west). Height of road is approximately 1.0 m		
30.5	Track LHS	Possible bus bay location (to check)	NA
32	Large canal (RHS) at 90o and then parallel (20 m from centerline)	Possible bus bay location (to check)	NA
33	Bridge and start of Kyaiklat	Possible transfer of river to road (possible bus bay (both sides)	NA
33.02 to 34.5	4.5 m plus gravel shoulders. Road less than 0.2 m above natural surface	Retain the existing centerline Construct a 7 m–7.2 m pavement with concrete edge or a concrete road. Height above needs to be as low as possible. Cross drains and side roads may control levels. Road may need to be excavated in order to construct adequate pavement. There are a number of cross drains adjacent to cross streets. Solution needs to be developed.	Power line 3.5 m on right. Telecom is 4 m on left.
34.5 to 35.5	4.5 m plus gravel shoulders which are approximately 3 m to 4 m wide. Road less than 0.2 m above natural surface	Retain the existing centerline As above except that pavement would be flanked by gravel shoulders. Local authorizes would have to deal with paving shoulders. There are a number of cross drains adjacent to cross streets. Solution needs to be developed.	Power line 8 m on right. Telecom is 8 m on left. Confirm
35.5	4 way intersection. Project road turns to the right. Road ahead is a local access road, road to left does to the river.	Part of intersection is already concrete. Intersection improvement is required, possibly a roundabout.	NA
35.6 to 36.2	5 m road wide road with 2.5 m (confirm) shoulders	Retain the existing centerline	Service both sides - clarification being sought
36.2 to 46	5 m plus sloping grassed shoulder of 4 m to 5 m each side and then another 2 m to 3 m of batter. Road	Retail centerline. Consider raising if in a flood area	Power line is 20 m on the LHS

Road Section (km)*	Description	Proposed Road Design/Construction Action/Comment	Issues
	approximately 0.9 m high		
38.3	Track RHS	Check if possible bus stop site	Power line is 20 m on the LHS
38.6	Small road	Possible bus stop and a short length of paving	NA
40.8	Track LHS (also bus stop structure)	Possible bus stop	NA
42.5	Curve leading to a bridge	Review curve	NA
43.8 to 44.2	Power line within 1 to 2 m of seal edge on RHS	Power line will need to be relocated	Power line within 1 m to 2 m of seal edge on RHS
45.5	Small road LHS	Possible bus stop and a short length of paving	NA
46.0 to 54.4	5 m plus sloping grassed shoulder of approximately 4 m each side and then another 2 to 3 m of batter. Road approximately 1 m high	Retail centerline (could move to the right). Consider raising if in a flood area	NA
46.7	Low radius curve	Review and consider improving	NA
47.8	Manhole (LHS – 6 m from centerline)	Could be retailed	Could be for optical fiber cable
48.7	Track on LHS	Check if possible bus stop site	NA
49.1	Track on LHS	Check if possible bus stop site	NA
50.0	Poor vertical alignment at bridge	Vertical alignment at bridge needs to be improved	Service both sides - clarification being sough
52.4	Track on RHS	Check if possible bus stop site	NA
53.4	Road (RHS)	Check if possible bus stop site	NA
54.3	Monument (RHS)	Will need to be moved	NA
54.4	Bridge (approach alignment is poor) End of project	Alignment will need to be improved	

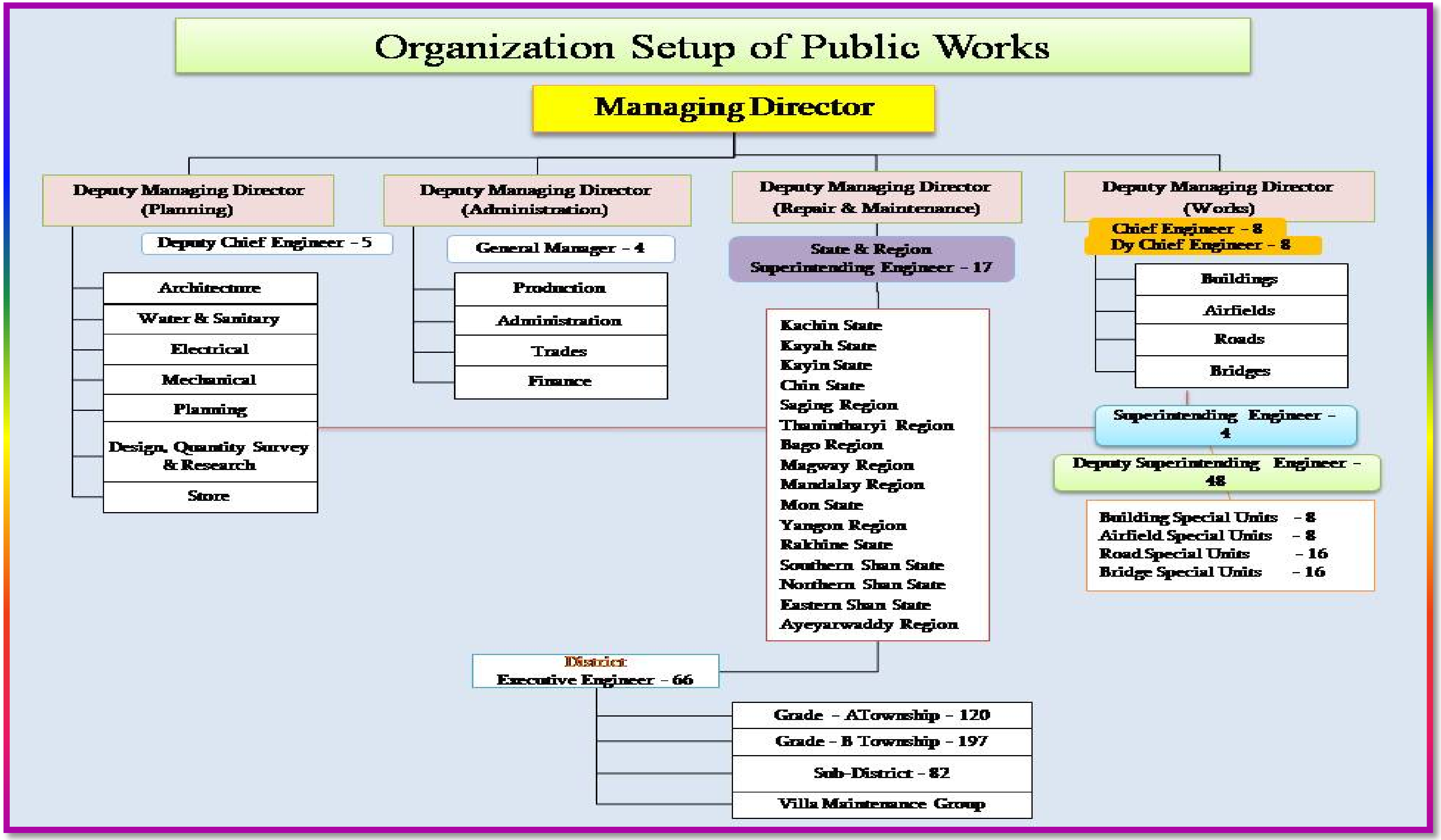
LHS = left hand side, m = meter, NA = not applicable, OFC = optical fiber cable, RHS = right hand side, ROW = right-of-way
* odometer reading
Note: Unless indicated otherwise the road level will be raised by at least 30 cm.
Source: Prepared by Consultant

MOC ROAD CONDITION ASSESSMENT – AYEYARWADDY REGION

			Good		Fair		Bad		Total
No.	Name of Road	Km	km	%	km	%	km	%	km
1	Pathein - Monywa	216.6	216.60	100%	-	-	-	-	216.60
2	Yangon - Pathein	99.6	99.60	100%	-	-	-	-	99.60
3	Pathein - Ngwesaung	47.2	40.40	86%	6.80	14%	-	-	47.20
4	Ngathainggyaung - Gwa	35.6	1.60	5%	13.80	39%	20.20	56%	35.60
5	Maubin - Kyaiklat	32.2	4.60	14%	18.20	57%	9.40	29%	32.20
6	Kyaiklat - Pyapon	17.6	-	-	17.60	100%	-	-	17.60
7	Pyapon - Bogale	30.8	30.80	100%	-	-	-	-	30.80
8	Kyeinpinse - Setkawt - Danubyu - Zalun	57.4	4.80	8%	6.40	11%	46.20	81%	57.40
9	Hinthada - Duya - Dauntgyi - Zalun - Danubyu	19.6	2.00	10%	15.80	81%	1.80	9%	19.60
10	Approach Road of Bo Myat Htun Bridge	6.4	6.40	100%	-	-	-	-	6.40
11	Hinthada - Songon - Myan-aung	104.4	37.60	36%	55.90	54%	10.90	10%	104.40
12	Myan-aung - Kyangin	7	3.80	54%	2.60	37%	0.60	9%	7.00
13	Kyangin - Phatye	13.8	1.80	13%	4.80	35%	7.20	52%	13.80
14	Danubyu - Thaunggyi	38.8	3.90	10%	9.40	24%	25.50	66%	38.80
15	Hinthada - Athok - Kyaunggon	16.8	6.00	36%	6.40	38%	4.40	26%	16.80
16	Approach Road of Kebaung Bridge	4.4	0.40	9%	0.40	9%	3.60	82%	4.40
17	Maubin - Sarmalauk	34.2	21.00	61%	13.20	39%	-	-	34.20
18	Twante - Maubin	24.2	24.20	100%	-	-	-	-	24.20
19	Dedaye - Pyapon	25.2	-	-	25.20	100%	-	-	25.20
20	Labutta - Myaungmya - Einme - Kyaunggon - Kyonpyaw	74	19.55	26%	49.45	67%	5.00	7%	74.00
	Total	**905.8**	**525.05**	**58%**	**245.95**	**27%**	**134.80**	**15%**	**905.80**

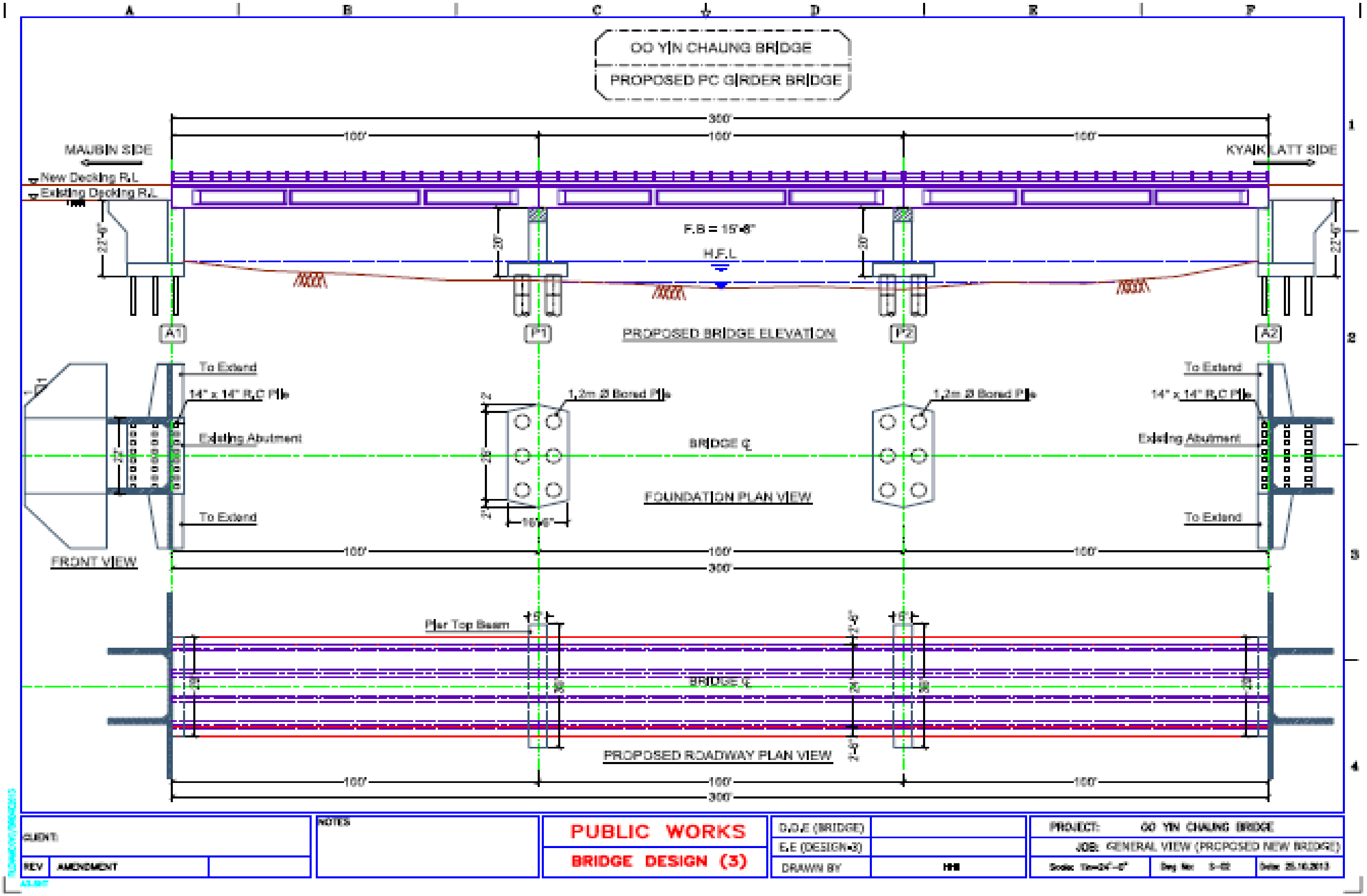
			Good		Fair		Bad		Total
No.	Name of Road	Km	km	%	km	%	km	%	km
21(1)	Maubin - Yelagale - Shwedaungmaw -Kyaikpi - Mawlamyinegyun	82.8	9.0	11%	65.8	79%	8.0	10%	82.80
22(2)	Mawlamyinegyun - Hlaingbone- Thitpoak - Kwinpouk- Pyinzalu	115.8	-	-	-	-	115.8	100%	115.8
23(3)	Labutta- Tingangyi – Pyinzalu	56.4	0.8	1%	-	-	55.6	99%	56.4
24(4)	Labutta- Kyaukphyarlay- Thongwa- Oaktwin- Hteiksun	99.8	16.6	17%	4.6	5%	78.6	78%	99.80
25(5)	Bogale-Kyeinchaung- Katonkani	66	-	-	-	-	66.0	100%	66.0
26(6)	Bogale- Setsan- Htawpine- Ama	61.8	-	-	-	-	61.8	100%	61.8
27(7)	Pyapon - Kyaonkadun - Dawyein - Ama	82.6	-	-	43.4	53%	39.2	47%	82.6
28(8)	Kyaonkadun- Setsan	30.6	-	-	7.2	24%	23.4	76%	30.6
29(9)	Pathein- Thalaikhwa- Mawtinsun	153.6	21.6	14%	132.0	86%	-	-	153.6
30(10)	Bogalae- Mawlamyinegyun- Wakema - Myaungmya	105.6	16.0	15%	47.4	45%	42.2	40%	105.60
31(11)	Pathein- Napudaw	32.4	29.6	91%	1.0	3%	1.8	6%	32.40
	Total	**887.4**	**93.6**	**11%**	**301.4**	**34%**	**492.4**	**55%**	**887.40**

PUBLIC WORKS ORGANIZATIONAL STRUCTURE



Source: Provided by MOC.

OO YIN CHAUNG BRIDGE – GENERAL ARRANGEMENT



MEETINGS

Meetings held during the study included those with PW and various private sector organizations including other project staff. There were also a number of technical presentations at which other PW staff, not listed below, attended.

Public Works Engineering

- U Han Soe, Deputy Managing Director;
- U Win Tint, Deputy Managing Director (works);
- U Thein Zaw, Chief Engineer, Building;
- U Win lwin, Deputy Chief Engineer;
- U Kyaw Shane, Deputy Chief Engineer, Planning Department;
- Daw Hla Hla Thwe, Superintending Engineer (Roads);
- Daw Thein Nu, Deputy Superintending Engineer, Bridge Department;
- Daw Mya Mya Win, Deputy Superintending Engineer, Road Research Laboratory;
- U Kyi Thwin Oo, Deputy Superintending Engineer, Road Special Unit No. 15;
- Daw Thandar Htun, Executive Engineer, Bridge Department;
- Daw Yin Yin Swe, Executive Engineer, Bridges, Road Research Laboratory;
- Daw Tin Tin Saw, Assistant Engineer, Road Research Laboratory;
- U Aung Myo Oo, District Engineer Phyapon;
- Daw Myint Myint Sein , District Engineer, Maubin;
- U Myint Oo, Executive Engineer, Roads Department;
- Daw Ei Ei Mon, Assistant Engineer, Roads Department;
- Daw Phyu Phyu, Assistant Engineer, Road Research Laboratory;
- Daw Su Mon Kyaw, Assistant Engineer, Phyapon;
- Daw Hnin Yu Aung, Junior Engineer, Road Research Laboratory
- U Win Naing, Public Works/Ministry of Construction
- U Ohn Maung, Public Works/Ministry of Construction
- U Hla Htay, Daw Khin Tint, Ministry of Construction
- U Aung Myint, Public Works Consultant.

Myanmar Post and Telecommunication

- U Wun Aung, Deputy Chief Engineer;
- U Soe Myint, Executive Engineer;
- U Zaw Htay. Assistant Engineer.

Engineering Private Sector

- U San Tun Aung, General Manager, Construction Engineering Group;
- U Than Win, Consultant, TZTM Group of Companies;
- U Win Naing Htun, Managing Director, Civil Solutions Consultants;
- Daw Yi Yi Khin, Director, Civil Solutions Consultants;
- Masataka Fujikuma, JICA Expert, Construction Supervision;
- Kazuki Ishida, Project Coordinator/Administrator;
- Hiroaki Kobayashi, JICA Expert, Construction Technology;
- Masaru Miyake, JICA Expert, Road Technical Standards;
- Koki Kaneda , JICA Expert, Road Planning and Assessment;
- Kirokazu Miyamoto, JICA Expert, Soils and Quality Control;
- Tha Htay, President, Myanmar Construction Entrepreneurs Association (MCEA);
- U Win Htay, Secretary, MCEA;
- Than Sin Myint, Planning Officer, MCEA

- U Myint Soe, Chief Executive Officer, Myanmar Engineers Society (MES)
- U Ban Zaw, Past President of MES and ex-Managing Director of Public Works;
- U Aung Thura Hliaing, Assistant Manager, Engineering Department, Concordia International
- U Thura Soe Senior Supervisor, Engineering Department, Concordia International
- U Zaw Moe, Director, Design, Materials, & QA/QC, Construction Engineering Group Co., Ltd;
- Daw Tin Aye Win, General Manager, IKBZ Insurance Company;
- U Chit Su Tun, Manager Operations, IKBZ Insurance Company;
- U San Kyaw Win, Assistant Engineer, Public Works/Ministry of Construction;
- Ye Htet Zaw, Sub-Assistant Engineer, Public Works/Ministry of Construction.

BRIDGE SCHEDULE

Physical Characteristics																
Location (mile)	**Location (Km)**	**Name of Bridge**	**Type**	**Length (ft)**	**Width (excluding footpath)**	**Design Load (tons)**	**Centreline Relocation**	**Relocated Underground Telecommunication Cable**	**Items to be removed/ demolished**	**Proposed Structural Work - Widening foundation, substructure and superstructure**	**Proposed Work Wingwalls**	**Abutment (including extensions)**	**Deck Treatment**	**Minor works/repairs**	**Road Safety Furtiture**	**Comments**
Maubin to Kyiaklat																
1.25	2.00	Kyar Ga Yey	Concrete Bridge	10	28	36	NO	NO	Guideposts and two sign footing	NONE	Raise wing wall height by approx 0.6 m and extend end by 0.75 metres (Right and Left)	NA	100 mm thick pavement will be constructed over the deck	Repair cracked wing wall	Guardrails will be constructed on approach, on bridge and on departure both sides	
1.63	2.60	Ngar Yit Sal	Concrete Pipe	3	50	10	1.0 m to right (east)	NO	Guideposts	Culvert underwater. Culver should be inspected pipe needs assessed	Demolosh Righ side headwall and construct a new headwall	NA	NA	None	Guaarrails will be constructed on approach and on departure both sides	
2.25	3.60	Kha Naung	Concrete Bridge	10	28	36	1.0 m to right (west)	Cable is to be relocated for a distance of 150 metre from each abutment CONFIRM??	Guideposts	NONE	On Left - raise wing wall height by approx 0.6 m and extend end by 0.75 metres; On Right - construct new wingwalls (to match left side)	NA	100 mm thick pavement will be constructed over the deck	None	Guardrails will be constructed on approach, on bridge and on departure both sides	
3.38	5.40	Pa Kout Toe	Concrete Pipe	3	50	10	3.5m to right (west)	NO	Guideposts	Culvert underwater. Culver should be inspected pipe needs assessed	Demolosh Righ side headwall and construct a new headwall	NA	NA	None	Guaarrails will be constructed on approach and on departure both sides	
3.75	6.00	Pa Kout Yoe	Concrete Bridge	15	28	36	Possibly 3.5m to right (west)	Cable is to be relocated for a distance of 150 metre from each abutment	Guideposts	NONE	Raise wing wall height by approx 0.6 m and extend end by 0.75 metres (Right and Left)	NA	100 mm thick pavement will be constructed over the deck	None	Guardrails will be constructed on approach, on bridge and on departure both sides	
6.25	10.00	Lat Tat Gyi Yoe	Concrete Bridge	15	28	10	3.5m to right (west)	Cable is to be relocated for a distance of 150 metre from each abutment	Guideposts	NONE	On Left - raise wing wall height by approx 0.6 m and extend end by 0.75 metres; On Right - construct new wingwalls (to match left side)	NA	100 mm thick pavement will be constructed over the deck	None	Guardrails will be constructed on approach, on bridge and on departure both sides	
7.25	11.60	Mayan Yoe	Concrete Pipe	3	50	10	3.5m to right (west)	NO	Guideposts	Culvert underwater. Culver should be inspected pipe needs assessed	Demolosh Righ side headwall and construct a new headwall	NA	NA	None	Guaarrails will be constructed on approach and on departure both sides	
7.88	12.60	Htein Pin Yoe	Concrete Bridge	10	28	36	3.5m to right (west)	Cable is to be relocated for a distance of 150 metre from each abutment CONFIRM??	Guideposts	NONE	On Left - raise wing wall height by approx 0.6 m and extend end by 0.75 metres; On Right - construct new wingwalls (to match left side)	NA	100 mm thick pavement will be constructed over the deck	None	Guaarrails will be constructed on approach, on bridge and on departure both sides	
10.63	17.00	Lata Gyi	Concrete Bridge	20	28	60	NO	Cable is to be relocated for a distance of 150 metre from each abutment	Guideposts	NONE	Raise wing wall height by approx 0.6 m and extend end by 0.75 metres (Right and Left)	NA	100 mm thick pavement will be constructed over the deck	None	Guardrails will be constructed on approach, on bridge and on departure both sides	
16.38	26.20	Oo Yin Chaung	Bailey	300	12	13	NO	Cable is to be relocated for a distance of 150 metre from each abutment	Part of the abutment and guideposts	New sub and superstructure and enlargement of abutment and abutment foundations	NA	Abutment Extensions	New deck	Ensure ends of kerb or walkways are ramped to shoulder level over a few metres	Guardrails will be constructed on approach and on departure both sides	By pass and temporary bridge is required. Verticle alignment needs to be corrected at approaches both ends
18.38	29.40	Kyee Chaung	Concrete Bridge	28	14	13	NO	Cable is to be relocated for a distance of 150 metre from each abutment	Guideposts	Possoble New or widened sub and superstructure and foundations	NA	New /Widned Structure	New deck	Ensure ends of kerb or walkways are ramped to shoulder level over a few metres	Guardrails will be constructed on approach and on departure both sides	By pass and temporary bridge is required. Verticle alignment needs to be corrected at approaches both ends
20.13	32.20	Hlal Sate	Concrete Bridge	90	24	60	NO	Cable is to be relocated for a distance of 150 metre north of bridge only and minor relocation to the south	Guideposts	NONE	NA	Extend (by 3 m) and raise abutment returns by 0.6 m (left and right) at north and south end	No action	Construct concrete ramp from shoulder level to top of kerb or walkways on bridge over a few metres	Guardrails will be constructed on approach and on departure both sides - side road on left (east) side at both end of bridge will require special attention	Clow speed area. Urban south of bridge and semi rural noth of the bridge. Bus stop is proposed on both sides of road, north of bridge
Kyiaklat to Pyapon																
1.50	37.60	Kha Naung	Concrete Bridge	100	28	60	NO	Cable is to be relocated for a distance of 150 metre from each abutment	Guideposts	NONE	NA		No action	Construct concrete ramp from shoulder level to top of kerb or walkways on bridge over a few metres	Guardrails will be constructed on approach, on bridge and on departure both sides	Verticle alignment needs to be corrected at approaches both ends
4.25	42.00	Gonhnyintan	Concrete Bridge	1940	28	60	NO	NO	Guideposts	NONE	NA	Extend (for full length of the batter protection) and raise abutment returns by 0.8 to 1.2 m (left and right) at north and south end	No action	Construct concrete ramp from shoulder level to top of kerb or walkways on bridge over a few metres	Guardrails will be constructed on approach, on bridge and on departure both sides	Verticle alignment needs to be corrected at approaches both ends
8.50	48.80	Thaleik Kyee	Concrete Bridge	180	28	60	NO	Cable is to be relocated for a distance of 150 metre from each abutment	Guideposts	NONE	NA	Extend (for 4 to 5 m) and raise abutment returns by 0.6 (left and right) at north and south end	No action	Construct concrete ramp from shoulder level to top of kerb or walkways on bridge over a few metres	Guardrails will be constructed on approach and on departure both sides	
9.13	49.80	Thaleik Kalay	Concrete Bridge	100	28	60	NO	Cable is to be relocated for a distance of 150 metre from each abutment	Guideposts	NONE	NA	Extend (for 3 to 4m) and raise abutment returns by 0.6 (left and right) at north and south end	No action	Construct concrete ramp from shoulder level to top of kerb or walkways on bridge over a few metres	Guardrails will be constructed on approach and on departure both sides	
11.00	52.80	Zchaung Twin	Concrete Bridge	236	28	60	NO	Cable is to be relocated for a distance of 150 metre north of bridge only and minor relocation to the south	Guideposts	NONE	NA	Extend (for 3 to 4m) and raise abutment returns by 0.6 (left and right) at north and south end	No action	Construct concrete ramp from shoulder level to top of kerb or walkways on bridge over a few metres	Guardrails will be constructed on approach and on departure both sides	