7. Development Concept and Priority Projects

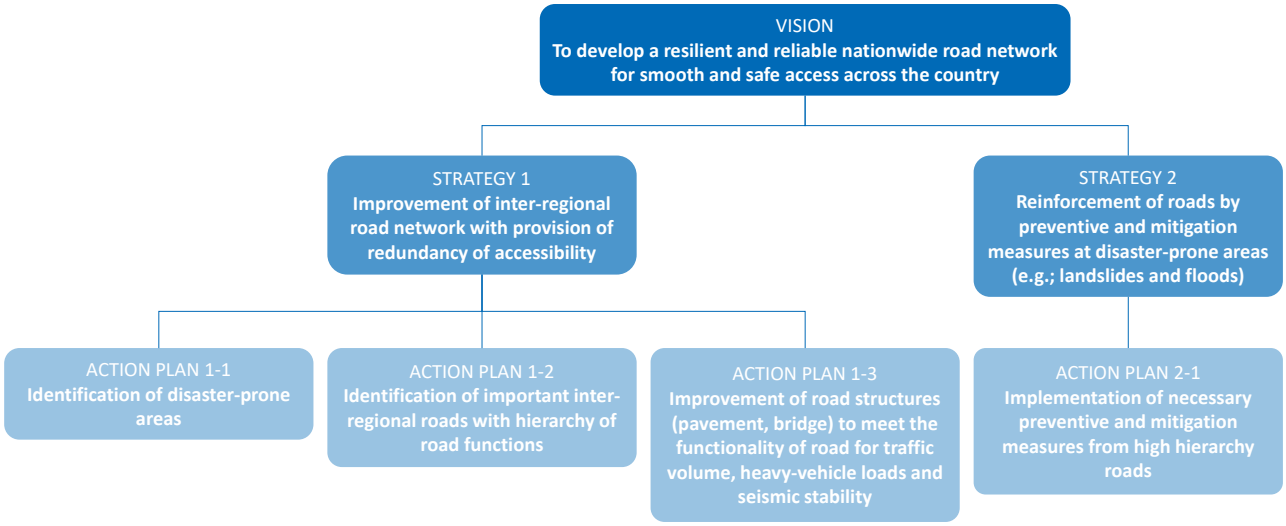
7.1 Development Concept for Building Disaster-Resilient Road Network

The road network in Myanmar needs a lot of improvement since its condition is poor as described in Chapter 2. The bad road surface sections are dominant in mountainous areas where the investment cost for improvement is comparatively high because of the necessity of cutting and filling of steep slopes for road widening and realignment since the most of the road sections do not meet the design standard for arterial roads.

In addition to the road surface and geometric conditions, the road sections in mountainous areas are susceptible to landslides. Many people reside in mountainous areas and roads are fundamental infrastructure to keep their lives.

In these regards, the road network should be developed not only for improvement of accessibility but also for building resilience against natural disasters. In order to efficiently improve the nationwide road network under the current budgetary constraint, it is necessary to implement road developments strategically through a comprehensive assessment of the current road network and evaluation of high-priority road sections.

Figure 7.1 summarizes the draft development policy of the nationwide road network, which includes vision, strategies and action plans. Considering that road is a fundamental infrastructure but is vulnerable against natural disasters, disaster-resilience should be put in place to support activities of people's daily living and emergency relief after natural disasters.



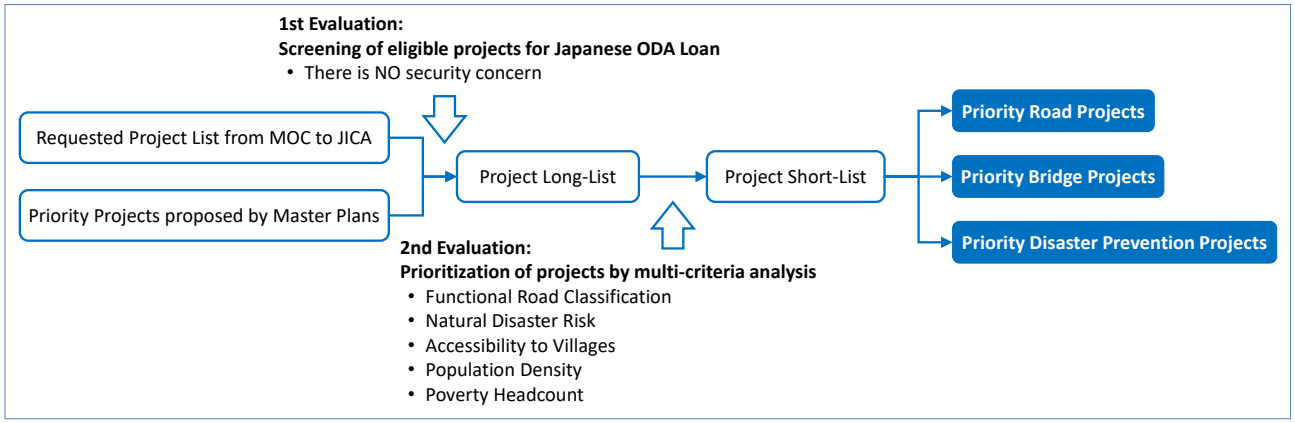
Source: JICA Study Team

Figure 7.1 Development Policy of Nationwide Road Network (Draft)

7.2 Methodology of Project Prioritization and Selection

In order to efficiently collect data/information and evaluate the necessity of improvement, priority projects were selected under the following steps. As the basis of evaluation, the nationwide road network was assessed and MOC's project need was also collected.

- Screening of eligible projects for Japanese ODA Loan project
- Identification of road sections necessary for improvement
- Prioritization of long-listed projects by evaluation of socio-economic indicators



Source: JICA Study Team

Figure 7.2 Procedure of Selection of Priority Projects

Due to the Coronavirus disease (COVID-19) pandemic situation, there was difficulty in visiting site for examination of the present situation of the roads and bridges. Therefore, this Study utilized available information/data provided by DOH as much as possible. Cost estimates also assumed a certain volumes of civil works based on the experience in the Regional Development for Poverty Reduction Project Phase I and Phase II and were determined in consideration of the possible typical cross sections.

Through these analysis, the Project Short-List was prepared for road projects, bridge projects and disaster prevention projects respectively. At the same time, the technical capacity of DOH, DOB and DRRD was assessed from the viewpoint of building disaster-resilient rural road network:

- **Road Projects** (may include bridge and box culvert construction)
- **Bridge Projects** (may include approach road)
- **Disaster Prevention Projects**

The project scope of the disaster prevention projects needs to be verified through further engineering examination such as site investigation, geotechnical investigation and topographic survey as well as examination of meteorological conditions. Therefore, this Study just presents examples of slope protection measure for reference.

7.3 Collection of Project Candidates

Candidates of the project were collected from MOC and the high-priority projects proposed by the upstream plans such as the National Transport Master Plan (NTMP) and National Logistics Master Plan (NLMP) are also included.

7.3.1 MOC's Proposal

MOC selected the road sections listed in **Table 7.1** for this study as the candidates of road project under Japanese ODA Loan. To be more effective and beneficial to social/economic activities and growth in Myanmar as well as the Sustainable Development Goals, MOC aspires to develop nationwide road network resilient against natural disasters through improvement of these road sections.

MOC also prepared the list of projects shown in **Table 7.2** in 2019 so that this Study evaluated the road sections listed in both **Table 7.1** and **Table 7.2** (the location of each road section is shown in **Figure 7.3**).

Table 7.1 MOC's Proposed Projects in 2020

No.	Name of Project	Road Length (km)	Location (State/Region)
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	67.58	Ayeyarwady
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	62.15	Ayeyarwady
2020-03	Thickegyin – Paungbyin – Homalin – Hkamti Road	539.00	Sagaing
2020-04	Htamamti – Leshi – Pan Sapsonemara Road	130.00	Sagaing
2020-05	Lahe – Yaungkon – Donhee – Nanyun Road	167.54	Sagaing
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	28.76	Bago
2020-07	Lapatan – Moenyo – Nattalin Road	110.80	Bago
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	127.92	Magway
2020-09	Minbu – Ann Road (Magway Section)	379.12	Magway
2020-10	Gangaw – Kalay Road	133.55	Magway
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	79.85	Tanintharyi
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	354.28	Mon
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	42.43	Kayin
2020-14	Pyi – Taungup Road	165.73	Rakhine
2020-15	Taungup – Thandwe Road	71.40	Rakhine
2020-16	Taungup – Maei – Kyaukpyu Road	192.22	Rakhine
2020-17	Aungmyin (Gangaw) – Aika Road	115.85	Chin
2020-18	Natt Chaung – Waibula – Bar Road	68.38	Chin
2020-19	Thanlwin Bridge (Hpa-An)	0.70	Kayin

Source: MOC. Ref. No.: 258/IRR/2020

Table 7.2 MOC's Proposed Projects in 2019

No.	Name of Project	Road Length (km)	Location (State/Region)
2019-01	Gangaw – Aika Road	94	Chin
2019-02	Mindat – Matupi Road	164	Chin
2019-03	Shwebo – Ye-U Road	36	Sagaing
2019-04	Ye-U – Kalaywa Road	372	Sagaing
2019-05	Thickegyin – Paungbyin – Homalin Road (Thickegyin – Paungbyin Section)	539	Sagaing
2019-06	Bellin – Yeywer – Pyinoolwin Road	58	Mandalay
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	78	Mandalay
2019-08	Dala – Letkokkon Road	58	Yangon
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	18	Yangon
2019-10	Tatkon – Expressway Link Road	30	Naypyitaw
2019-11	Taungoo – Mawchi – Loikaw Road (Baw Ga Li – Hpasawng section)	176	Kayah
2019-12	Labo – Mingin – Myoma Road	41	Sagaing
2019-13	Tarlay – Pershoe – Kenglat Road	56	Shan (Eastern)

Source: MOC. Ref. No.: QAQC/JICA/2018-2019/311

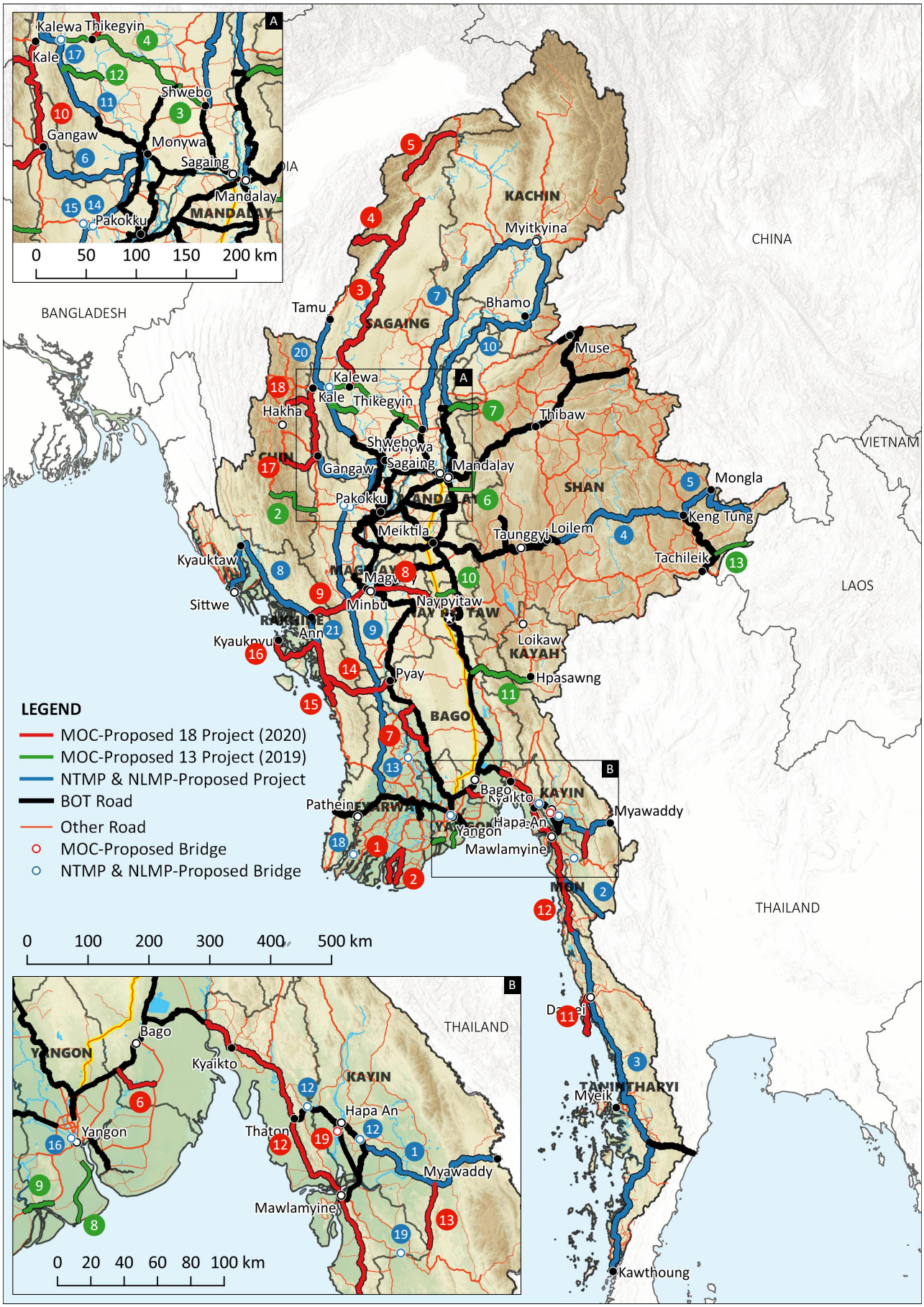
7.3.2 Other Important Road Sections

In addition to the MOC-proposed road sections, the road sections and bridges proposed by NTMP and NLMP, which have not been implemented, are included in the evaluation but the BOT roads are excluded (see **Table 7.3**).

Table 7.3 NTMP and NLMP-Proposed Priority Projects (Short- to Mid-Term)

No.	NTMP ID	NLMP ID	Name of Project	Road Length (km)	Location (State/Region)
MP-01	R001	LRP-15	Thaton – Eindu – Kawkareik – Myawaddy Road	192	Kayin
MP-03	R003	LRP-34	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	934	
MP-04	R004	LRP-37	Taunggyi – Loilim – Kyaington Road	677	Shan
MP-05	R005	LRP-52	Kyaing Tung – Mongla Road	93	Shan
MP-06	R006	LRP-41	Monywa - Pale - Gangaw – Kalaymyo Road	311	Sagaing / Magway
MP-07	R007	LRP-35	Shwebo – Myitkyina Road	476	Sagaing /Kachin
MP-08	R008	LRP-29	Minbu – Ann – Kyauktaw – Sittwe Road	477	Rakhine
MP-09	R011	LRP-51	Monywa – Pathein Road	721	Sagaing/Magway/ Bago/ Ayeyarwady
MP-10	R013	LRP-40	Mandalay – Thabeikkyin – Tagaung – Bhamo Road	282	Mandalay/Sagaing/ Kachin
MP-11	R017	LRP-42	Monywa – Yargyi – Kalewa Road	186	Sagaing
MP-13	R028	LRP-48	Hinthada Bridge	3.83	Ayeyarwady
MP-16	R032	LRP-47	Hlaing River Bridge	1.20	Yangon
MP-18	R037	LRP-49	Thetkal Thoung Bridge	0.76	Ayeyarwady
MP-21	-	LRP-14	Ann – Kyaukpyu Road	192	Rakhine

Source: NTMP, NLMP



Source: MOC. Ref. No.: 258/IRR/2020, QAQC/JICA/2018-2019/311

Figure 7.3 Proposed Road and Bridge Projects (MOC, NTMP & NLMP)

7.4 Screening of Eligible Projects for Japanese ODA Loan Project

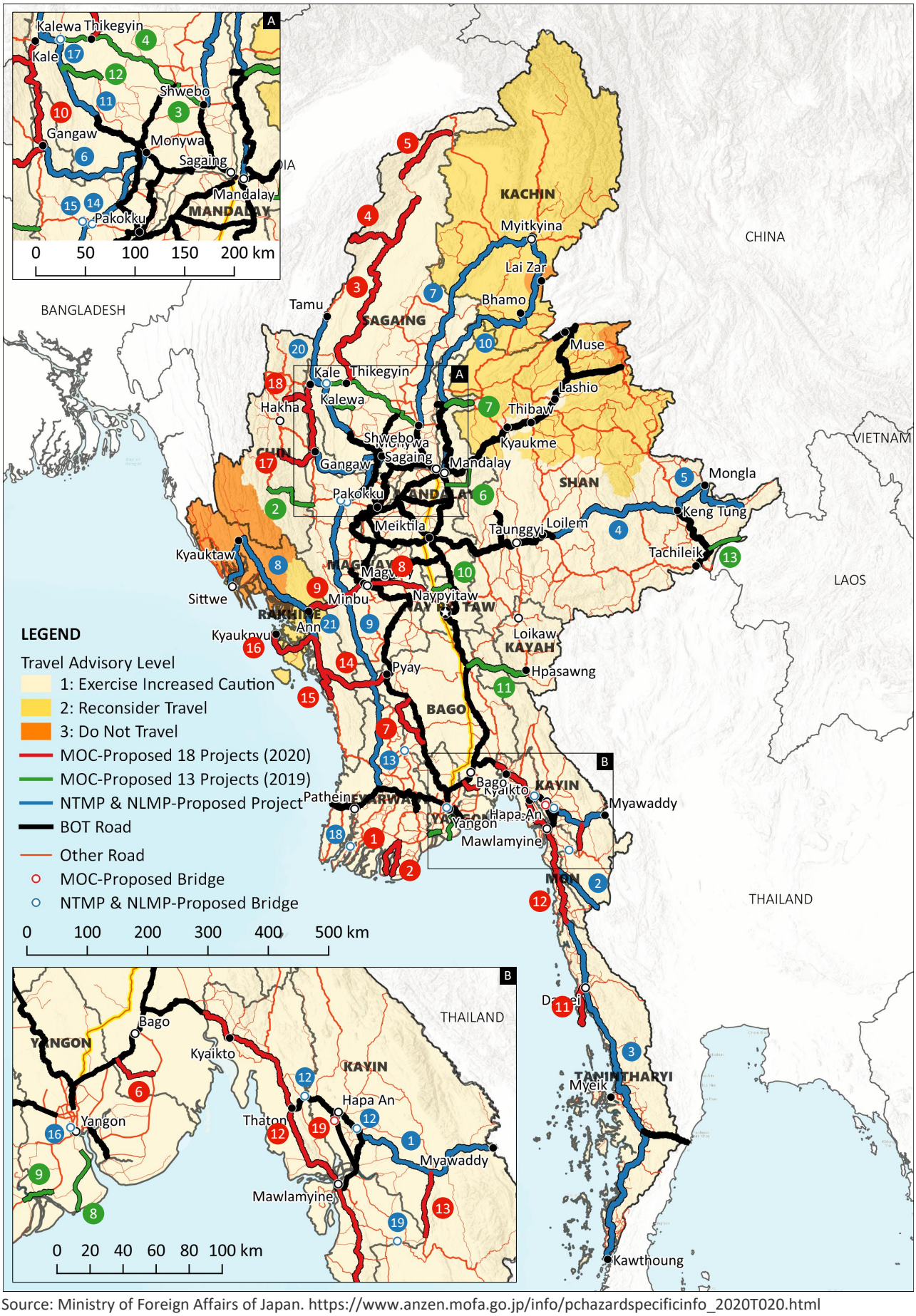
As the first evaluation, the eligible projects for Japanese ODA Loan project were selected mainly from the view point of security concern and the following information were used as references of the security level. In the Regional Development for Poverty Reduction Project Phase I, improvement of one of the proposed road sections was cancelled because of the difficulty in implementing civil works due to strong resistance by a local ethnic armed organization. Therefore, project implementability is the first concern of project formulation.

- Security advice from the Ministry of Foreign Affairs of Japan
- Ethnic Armed Organization (EAO) active areas.

Table 7.4 Result of Screening of Eligible Projects for Japanese ODA Loan Project

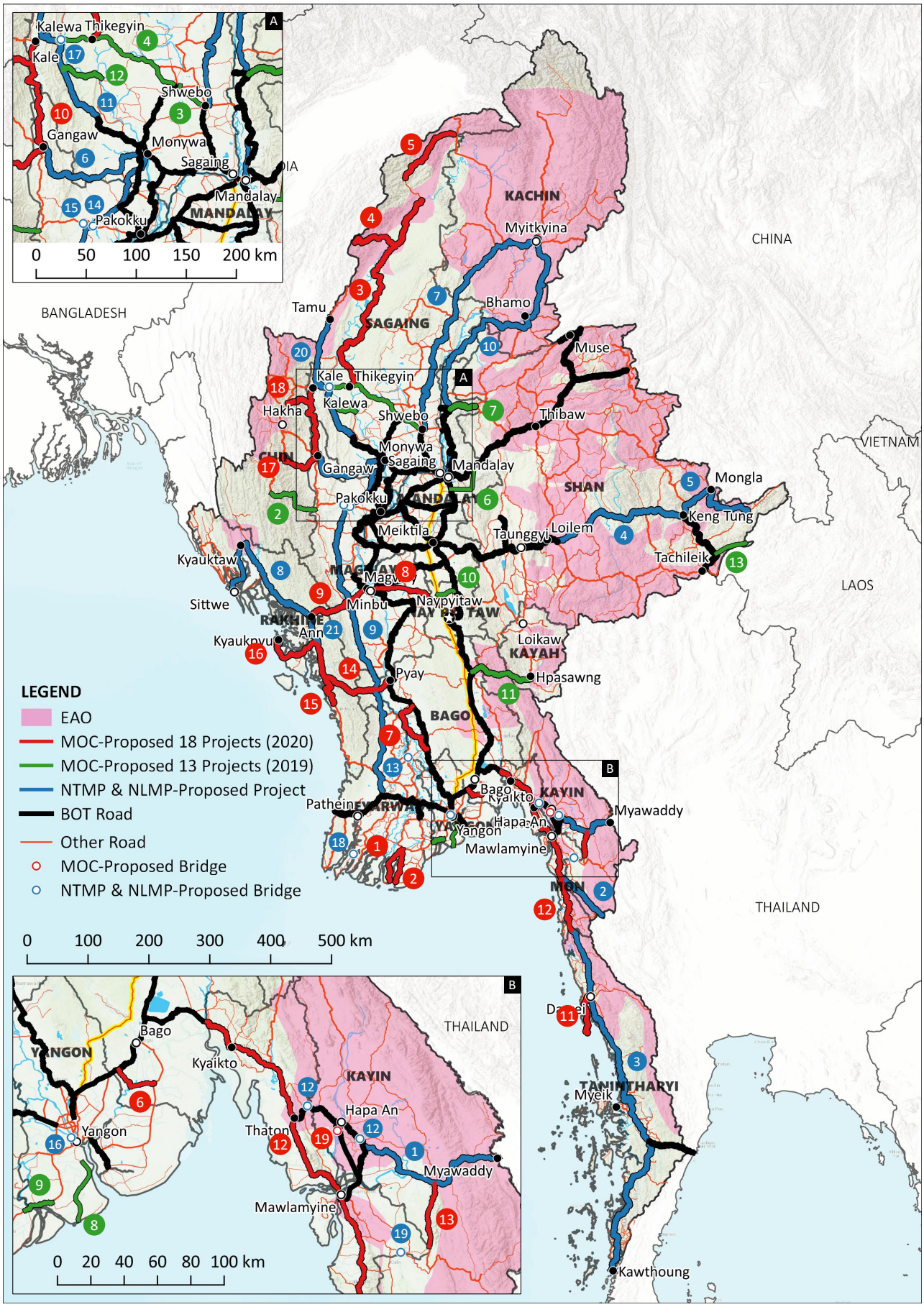
No.	Name of Project	Location	Travel Advisory	EAO Active Area	Evaluation
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	AYE		-	**PASS**
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	AYE		-	**PASS**
2020-03 2019-05	Thickegyin – Paungbyin – Homalin – Hkamti Road	SAG		-	**PASS**
2020-04	Htamamti – Leshi – Pan Sapsonemara Road	SAG		✓	FAIL
2020-05	Lahe – Yaungkon – Donhee – Nanyun Road	SAG		✓	FAIL
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	BAG		-	**PASS**
2020-07	Lapatan – Moenyo – Nattalin Road	BAG		-	**PASS**
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	MAG		-	**PASS**
2020-09	Minbu – Ann Road (Magway Section)	MAG	Partially 2	-	**PASS**
2020-10	Gangaw – Kalay Road	MAG		-	**PASS**
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	TAN		-	**PASS**
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	MON		-	**PASS**
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	KYN		-	**PASS**
2020-14	Pyi – Taungup Road	RAK		-	**PASS**
2020-15	Taungup – Thandwe Road	RAK		-	**PASS**
2020-16	Taungup – Maei – Kyaukpyu Road	RAK	Partially 2	-	**PASS**
2020-17 2019-01	Aungmyin (Gangaw) – Aika Road	CHI		-	**PASS**
2020-18	Natt Chaung – Waibula – Bar Road	CHI		-	**PASS**
2020-19	Thanlwin Bridge (Hpa-An)	KYN		-	**PASS**
2019-02	Mindat – Matupi Road	CHI		-	**PASS**
2019-03	Shwebo – Ye-U Road	SAG		-	**PASS**
2019-04	Ye-U – Kalaywa Road	SAG		-	**PASS**
2019-06	Bellin – Yeywer – Pyinoolwin Road	MAN			**PASS**
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	MAN		-	**PASS**
2019-08	Dala – Letkokkon Road	YAN		-	**PASS**
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	YAN		-	**PASS**
2019-10	Tatkon – Expressway Link Road	NAY		-	**PASS**
2019-11	Taungoo – Mawchi – Loikaw Road (Baw Ga Li – Hpasawng section)	KYH		✓	FAIL
2019-12	Labo – Mingin – Myoma Road	SAG		-	**PASS**
2019-13	Tarlay – Pershoe – Kenglat Road	SHA		✓	FAIL
MP-01	Thaton – Eindu – Kawkareik – Myawaddy Road	KYN		Partially✓	**PASS**
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	MON/TAN		Partially✓	**PASS**
MP-04	Taunggyi – Loilim – Kyaington Road	SHA		✓	FAIL
MP-05	Kyaing Tung – Mongla Road	SHA		✓	FAIL
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	SAG/MAG			**PASS**
MP-07	Shwebo – Myitkyina Road	SAG/KAC	Partially 2	Partially✓	**PASS**
MP-08	Minbu – Ann – Kyauktaw – Sittwe Road	RAK	2 – 3	Partially✓	FAIL
MP-09	Monywa – Pathein Road	SAG/MAG/BAG /AYE			**PASS**
MP-10	Mandalay – Thabeikkyin – Tagaung – Bhamo Road	MAN/SAG/KAC	Partially 2	Partially✓	FAIL
MP-11	Monywa – Yargyi – Kalewa Road	SAG			**PASS**
MP-13	Hinthada Bridge	AYE			**PASS**
MP-16	Hlaing River Bridge	YAN			**PASS**
MP-18	Thetkal Thoung Bridge	AYE			**PASS**
MP-21	Ann – Kyaukpyu Road	RAK	2		**PASS**

Source: JICA Study Team



Source: Ministry of Foreign Affairs of Japan. https://www.anzen.mofa.go.jp/info/pchazardspecificinfo_2020T020.html

Figure 7.4 Proposed Projects and Security Advisory in Myanmar



Source: Burma News Int. Deciphering Myanmar's Peace Process, A Reference Guide 2017-2018

Figure 7.5 Proposed Projects and Ethnic Armed Organization Active Area

As shown in **Table 7.4**, some of the road sections are partially located within the high-security risk areas but these road sections (excluding MP-08) were not disqualified because the high-security risk sections can be eliminated in later evaluation stage and only MP-08 was disqualified because whole section of MP-08 is located within the area of the security levels 2 and 3.

The road sections of 2020-04, 2020-05, 2019-11, 2019-13, MP-04, MP-05 and MP-10 were disqualified because majority of the road sections of them are located within the EAO active areas.

As the result of the first evaluation, the 32 road sections and 4 bridge projects listed in **Table 7.5** passed and are incorporated as a project long-list.

Table 7.5 Project Long-List

No.	Name of Road Sections	Road Length (km)	Location
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	67.58	AYE
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	62.15	AYE
2020-03 2019-05	Thickegyin – Paungbyin – Homalin – Hkamti Road	539.00	SAG
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	28.76	BAG
2020-07	Lapatan – Moenyo – Nattalin Road	110.80	BAG
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	127.92	MAG
2020-09	Minbu – Ann Road (Magway Section)	379.12	MAG
2020-10	Gangaw – Kalay Road	133.55	MAG
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	79.85	TAN
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	354.28	MON
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	42.43	KYN
2020-14	Pyi – Taungup Road	165.73	RAK
2020-15	Taungup – Thandwe Road	71.40	RAK
2020-16	Taungup – Maei – Kyaukpyu Road	192.22	RAK
2020-17 2019-01	Aungmyin (Gangaw) – Aika Road	115.85	CHI
2020-18	Natt Chaung – Waibula – Bar Road	68.38	CHI
2020-19	Thanlwin Bridge (Hpa-An)	0.70	KYN
2019-02	Mindat – Matupi Road	164	CHI
2019-03	Shwebo – Ye-U Road	36	SAG
2019-04	Ye-U – Kalaywa Road	372	SAG
2019-06	Bellin – Yeywer – Pyinoolwin Road	58	MAN
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	78	MAN
2019-08	Dala – Letkokkon Road	58	YAN
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	18	YAN
2019-10	Tatkon – Expressway Link Road	30	NAY
2019-12	Labo – Mingin – Myoma Road	41	SAG
MP-01	Thaton – Eindu – Kawkareik – Myawaddy Road	192	KYN
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	934	MON/TAN
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	311	SAG/MAG
MP-07	Shwebo – Myitkyina Road	476	SAG/KAC
MP-09	Monywa – Pathein Road	721	SAG/MAG/BAG/AYE
MP-11	Monywa – Yargyi – Kalewa Road	186	SAG
MP-13	Hinthada Bridge	3.83	AYE
MP-16	Hlaing River Bridge	1.20	YAN
MP-18	Thetkal Thoung Bridge	0.76	AYE
MP-21	Ann – Kyaukpyu Road	192	RAK

Source: JICA Study Team

7.5 Analysis of Current Conditions of Long-Listed Road Sections

Due to the restrictions on movement in Myanmar caused by the COVID-19 pandemic, there was difficulty to carry out site survey under this study. Therefore, evaluation of the necessity of improvement was made based on the following data provided by DOH regional offices:

- Pavement type
- Road surface condition
- Pavement (carriageway) width
- Bridge length
- Bridge width
- Bridge Type
- Allowable load (ton)

Pavement type, road surface condition and pavement width are summarized in Table 7.6, Table 7.7, Table 7.8 and Figure 7.7 respectively and the details of the road inventories are compiled in the **Appendix-2**. There are some inconsistency with the total lengths between Table 7.6, Table 7.7 and Table 7.8 but these are due to incompleteness of the road inventory data.

(1) Pavement Type

There are six (6) pavement types used on the long-listed road sections, namely asphalt concrete pavement (ACP), Portland cement concrete pavement (PCCP), penetration macadam pavement (PMP), crushed rock, gravel and earth. Whereas asphalt concrete pavement, Portland cement concrete pavement and penetration macadam pavement would be sufficient for DOH's arterial roads, 80% (3,475 km) of the whole sections of the long-listed road sections meet the requirement and the remaining 20% (875 km) need improvement in terms of pavement type.

However, the durability of the penetration macadam pavement is not so high and is easily deteriorated by heavy-vehicle traffic. 78% of the road sections may still need to be improved if it target international standard.

Portland Cement Concrete Pavement

Portland Cement Concrete Pavement

Penetration Macadam Pavement

Earth Road

Source: JICA Study Team

Figure 7.6 Difference in Pavement Type

Table 7.6 Pavement Types

No.	Name of Road Sections	Road Length (km)						
		ACP	PCCP	PMP	Crushed Rock	Gravel	Earth	Total
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	0.0	0.0	16.4	0.0	51.2	0.0	67.6
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	0.0	0.0	19.5	0.0	9.7	33.0	62.2
2020-03	Thickegyin – Paungbyin – Homalin – Hkamti Road	1.0	52.6	3.0	0.0	479.4	0.0	536.0
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	0.0	1.1	27.5	0.0	0.0	0.0	28.6
2020-07	Lapatan – Moenyo – Nattalin Road	0.0	0.0	64.1	34.6	11.5	0.0	110.2
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	0.0	4.8	31.8	0.0	0.0	0.0	36.6
2020-09	Minbu – Ann Road (Magway Section)	0.0	0.0	107.2	0.0	0.0	0.0	107.2
2020-10	Gangaw – Kalay Road	8.1	0.0	125.5	0.0	0.0	0.0	133.6
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	3.5	0.0	76.3	0.0	0.0	0.0	79.9
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	127.8	0.0	44.4	0.0	0.0	0.0	172.2
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	48.4	0.0	46.5	0.0	0.0	0.0	95.0
2020-14	Pyi – Taungup Road	0.0	0.0	89.1	0.0	0.0	0.0	89.1
2020-15	Taungup – Thandwe Road	0.0	2.7	35.1	0.0	0.0	0.0	37.8
2020-16	Taungup – Maei – Kyaukpyu Road	0.0	7.2	185.7	0.0	0.0	0.0	192.9
2020-17	Aungmyin (Gangaw) – Aika Road	0.0	0.0	17.4	7.5	39.8	29.8	94.5
2020-18	Natt Chaung – Waibula – Bar Road	0.0	0.0	9.3	16.3	0.0	38.8	64.4
2019-02	Mindat – Matupi Road	1.6	0.4	162.1	0.0	0.0	0.0	164.2
2019-03	Shwebo – Ye-U Road	0.0	0.0	36.6	0.0	0.0	0.0	36.6
2019-04	Ye-U – Kalaywa Road	5.5	59.3	92.8	13.3	1.1	0.0	172.1
2019-06	Bellin – Yeywer – Pyinoolwin Road	0.0	16.3	13.0	0.0	0.0	29.4	58.7
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	0.0	0.0	78.9	0.0	0.0	0.0	78.9
2019-08	Dala – Letkokkon Road	0.0	57.9	0.0	0.0	0.0	0.0	57.9
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	0.0	18.3	0.0	0.0	0.0	0.0	18.3
2019-10	Tatkon – Expressway Link Road	0.0	30.8	0.0	0.0	0.0	0.0	30.8
2019-12	Labo – Mingin – Myoma Road	0.0	41.0	0.0	0.0	0.0	0.0	41.0
MP-01	Thaton – Eindu – Kawkareik – Myawaddy Road	164.4	0.0	0.4	0.0	0.0	0.0	164.8
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	193.2	68.3	534.7	0.2	0.0	1.0	797.4
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	0.0	1.2	194.7	0.0	0.0	0.0	195.9
MP-07	Shwebo – Myitkyina Road	3.5	44.8	232.0	0.0	0.0	0.0	280.2
MP-09	Monywa – Pathein Road	0.0	0.0	41.6	0.0	0.0	0.0	41.6
MP-11	Monywa – Yargyi – Kalewa Road	0.0	0.0	32.7	15.2	20.8	42.7	111.4
MP-21	Ann – Kyaukpyu Road	0.0	3.2	189.7	0.0	0.0	0.0	192.9
Total		**557.0**	**409.9**	**2,508.0**	**87.1**	**613.5**	**174.7**	**4,350.5**
Necessity of improvement for minimum standard		**3,474.9 (80%)**			**875.3 (20%)**			**100%**
Necessity of improvement for international standard		**966.9 (22%)**		**3,383.3 (78%)**				**100%**

ACP: Asphalt Concrete Pavement, PCCP: Portland Cement Concrete Pavement, PMP: Penetration Macadam Pavement
Source: DOH

(2) Road Surface Condition

The road surface conditions are evaluated by DOH using three (3) conditions, namely "good", "fair" and "bad". It was not possible to confirm the actual conditions of them due to the restriction by COVID-19 pandemic and thus this study assumed that the condition "bad" would be the status of necessity of road improvement.

The "bad" road sections accounts for 16% (683 km) of the whole sections of the long-listed road sections and should be improved in terms of road surface condition.

Table 7.7 Road Surface Condition

No.	Name of Road Sections	Road Length (km)			
		Good	Fair	Bad	Total
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	4.1	63.4	0.0	67.6
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	43.3	18.9	0.0	62.2
2020-03	Thickegyin – Paungbyin – Homalin – Hkamti Road	336.9	122.1	80.1	539.0
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	18.3	7.7	2.6	28.6
2020-07	Lapatan – Moenyo – Nattalin Road	55.3	35.7	19.2	110.2
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	25.0	11.5	0.1	36.6
2020-09	Minbu – Ann Road (Magway Section)	19.1	26.3	5.7	51.1
2020-10	Gangaw – Kalay Road	86.0	42.4	5.2	133.6
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	56.9	23.0	0.0	79.9
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	151.6	4.8	15.8	172.2
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	55.0	23.3	16.8	95.0
2020-14	Pyi – Taungup Road	12.4	51.7	25.1	89.1
2020-15	Taungup – Thandwe Road	38.4	24.6	8.4	71.4
2020-16	Taungup – Maei – Kyaukpyu Road	64.5	90.8	37.6	192.9
2020-17	Aungmyin (Gangaw) – Aika Road	38.9	17.3	38.4	94.5
2020-18	Natt Chaung – Waibula – Bar Road	5.9	36.6	21.8	64.4
2019-02	Mindat – Matupi Road	67.2	46.5	50.9	164.6
2019-03	Shwebo – Ye-U Road	4.9	22.9	8.8	36.6
2019-04	Ye-U – Kalaywa Road	55.4	94.1	23.0	172.5
2019-06	Bellin – Yeywer – Pyinoolwin Road	9.8	19.1	29.8	58.7
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	46.3	20.4	12.1	78.9
2019-08	Dala – Letkokkon Road	27.4	27.3	3.3	57.9
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	1.8	15.5	1.0	18.3
2019-10	Tatkon – Expressway Link Road	30.8	0.0	0.0	30.8
2019-12	Labo – Mingin – Myoma Road	37.9	0.0	3.2	41.1
MP-01	Thaton – Eindu – Kawkareik – Myawaddy Road	164.4	0.4	0.0	164.8
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	422.9	303.1	71.4	797.4
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	138.7	28.4	28.8	195.9
MP-07	Shwebo – Myitkyina Road	167.6	73.3	39.3	280.2
MP-09	Monywa – Pathein Road	31.2	10.4	0.0	41.6
MP-11	Monywa – Yargyi – Kalewa Road	35.3	34.2	52.5	122.1
MP-21	Ann – Kyaukpyu Road	32.4	78.8	81.7	192.9
Total		**2,285.6**	**1,374.5**	**682.6**	**4,342.6**
Necessity of improvement		**3,660.1 (84%)**		**682.6 (16%)**	**100%**

Source: DOH

(3) Road Width

The on-going Regional Development Project for Poverty Reduction Project Phase I and II applied 5.5 m pavement width as the carriageway for both directions (2.75 m width for each direction) and thus this study assume that 5.5 m is the minimum requirement for DOH's arterial roads (although DOH's design standard specifies the standard width as 7.0 m).

38% (1,507 km) of the whole sections of the long-listed road sections have narrower width than 5.5 m and needs improvement in terms of road width.

Table 7.8 Road Width

No.	Name of Road Sections	Road Length (km)				
		5.5m-(18ft)	4.88m (16ft)	3.66m (12ft)	2.44m (8ft)	Total
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	-	-	16.4	-	16.4
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	-	-	19.5	-	19.5
2020-03	Thickegyin – Paungbyin – Homalin – Hkamti Road	52.6	-	482.4	-	535.0
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	26.6	-	2.0	-	28.6
2020-07	Lapatan – Moenyo – Nattalin Road	2.2	2.1	66.0	38.3	108.6
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	26.8	-	9.8	-	36.6
2020-09	Minbu – Ann Road (Magway Section)	107.2	-	-	-	107.2
2020-10	Gangaw – Kalay Road	133.6	-	-	-	133.6
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	52.1	-	24.2	-	76.3
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	172.2	-	-	-	172.2
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	95.0	-	-	-	95.0
2020-14	Pyi – Taungup Road	10.1	-	79.1	-	89.1
2020-15	Taungup – Thandwe Road	9.1	-	28.7	-	37.8
2020-16	Taungup – Maei – Kyaukpyu Road	57.6	-	70.7	-	128.3
2020-17	Aungmyin (Gangaw) – Aika Road		-	17.4	-	17.4
2020-18	Natt Chaung – Waibula – Bar Road	1.6	-	46.5	-	48.1
2019-02	Mindat – Matupi Road	4.6	-	159.5	-	164.2
2019-03	Shwebo – Ye-U Road	13.6	-	23.0	-	36.6
2019-04	Ye-U – Kalaywa Road	78.9	-	93.2	-	172.1
2019-06	Bellin – Yeywer – Pyinoolwin Road	15.2	-	43.5	-	58.7
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	78.9	-	-	-	78.9
2019-08	Dala – Letkokkon Road	29.5	7.9	20.6	-	57.9
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	6.2	6.5	5.7	-	18.3
2019-10	Tatkon – Expressway Link Road	30.8	-	-	-	30.8
2019-12	Labo – Mingin – Myoma Road	4.0	-	16.4	20.6	41.0
MP-01	Thaton – Eindu – Kawkareik – Myawaddy Road	164.8	-	-	-	164.8
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	787.2	-	10.2	-	797.4
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	174.6	-	20.2	-	194.7
MP-07	Shwebo – Myitkyina Road	280.2	-	-	-	280.2
MP-09	Monywa – Pathein Road	22.9	-	18.7	-	41.6
MP-11	Monywa – Yargyi – Kalewa Road	15.5	-	78.7	-	94.2
MP-21	Ann – Kyaukpyu Road	45.6	-	79.3	-	124.9
Total		**2,499.2**	**16.5**	**1,431.7**	**58.9**	**4,006.0**
Necessity of improvement		**2,499.2 (62%)**	**1,507.1 (38%)**			**100%**

Source: DOH

Figure 7.7 summarizes the abovementioned road conditions by road length (above) and by share (bottom). The blue colored portions represent the necessity of improvement described earlier.

As shown in the graphs of pavement type, most of the road sections are paved with sufficient pavement types (namely, asphalt concrete pavement, Portland cement concrete pavement and penetration macadam pavement) but six (6) road sections of the list of year-2020 (2020-01, 02, 03, 07, 17 and 18) and one (1) road section of the list of year-2019 (2019-06) are not with the standard level. There is no clear relationship between pavement type and road surface condition but the road surface conditions and road widths of abovementioned seven (7) roads are relatively bad.

Source: DOH

Figure 7.7 Current Road Conditions of Long-Listed Road Sections

(4) Bridge Conditions

There are plenty of bridges on the long-listed road sections but this study focused only on bridges longer than 15 m out of them. According to the DOH's bridge inventories, there are 122 long-length bridges with its length longer than 55 m (180 ft) and 347 medium-length bridges with its length from 15 m (50 ft) to 55 m (180 ft). The accumulated total bridge length on the 4,350 km road sections is 34.9 km (0.8% of the road length).

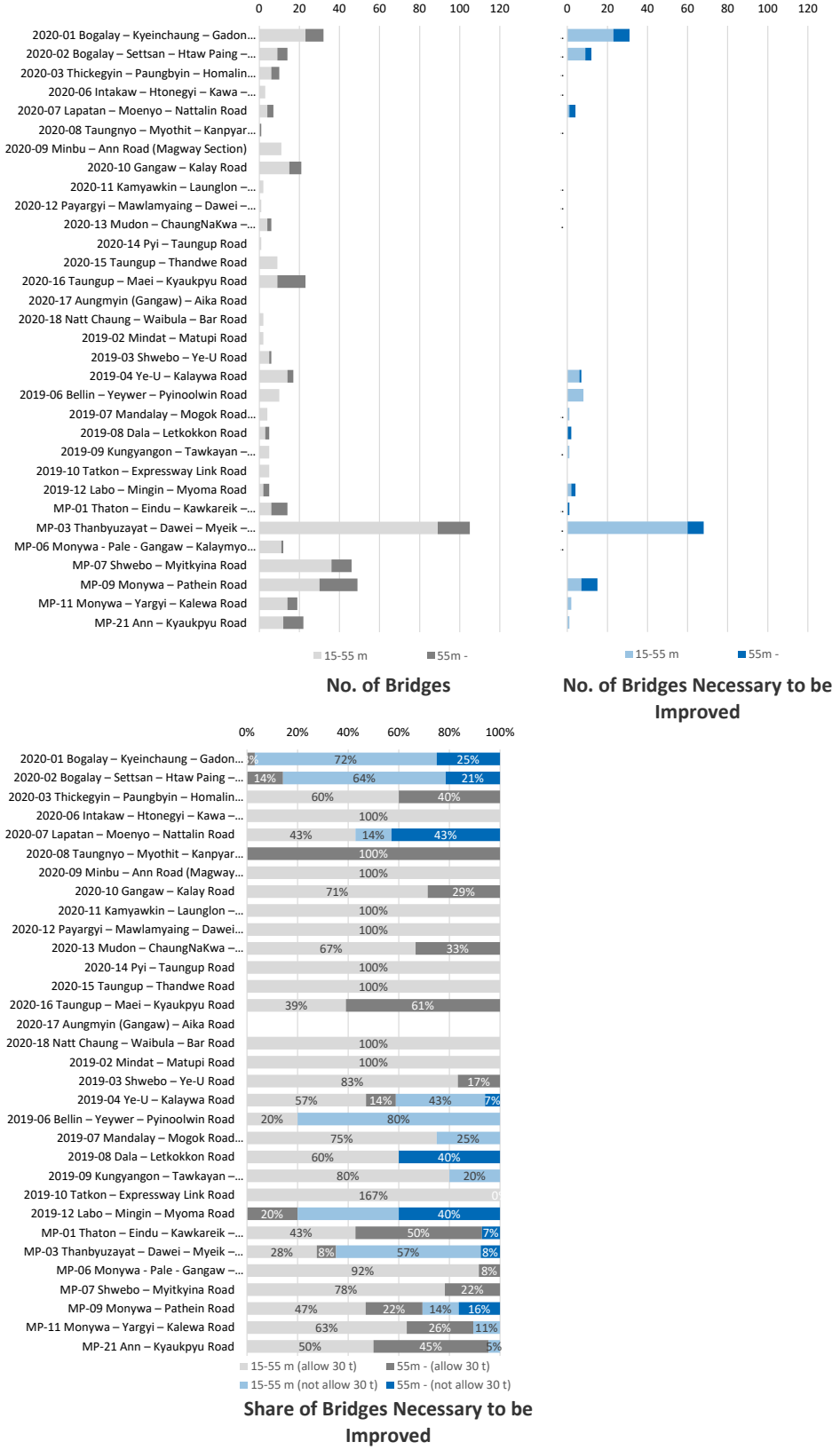
The structural types of bridges are classified into reinforced concrete (RC), steel, bailey, wooden but it is difficult to justify the necessity of improvement only from the bridge type. The bridge inventories include allowable load in ton of each bridge so that this study evaluated the necessity of bridge improvement only from the allowable load. Considering that 30 t would be the minimum requirement for DOH's arterial roads, 37 long-length bridges and 121 medium-length bridges (accumulated total bridge length is 10.1 km, 29% of whole bridges) need to be reconstructed due to the allowable load condition.

Table 7.9 Bridge Conditions

No.	Name of Project	No. of Bridges			Bridge Length		Necessity of Improvement			
		Bridge Length 15-55m	Bridge Length 55m-	Total	Max. (m)	Total (m)	Bridge Length 15-55m	Bridge Length 55m-	Total	Total Length (m)
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	23	9	32	1,083	2,901	23	8	31	1,818
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	9	5	14	704	1,982	9	3	12	735
2020-03	Thickegyin – Paungbyin – Homalin – Hkamti Road	6	4	10	122	515	0	0	0	0
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	3	0	3	31	70	0	0	0	0
2020-07	Lapatan – Moenyo – Nattalin Road	4	3	7	274	527	1	3	4	445
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	0	1	1	67	67	0	0	0	0
2020-09	Minbu – Ann Road (Magway Section)	11	0	11	46	332	0	0	0	0
2020-10	Gangaw – Kalay Road	15	6	21	181	1,066	0	0	0	0
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	2	0	2	18	35	0	0	0	0
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	1	0	1	18	18	0	0	0	0
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	4	2	6	280	481	0	0	0	0
2020-14	Pyi – Taungup Road	1	0	1	18	18	0	0	0	0
2020-15	Taungup – Thandwe Road	9	0	9	55	281	0	0	0	0
2020-16	Taungup – Maei – Kyaukpyu Road	9	14	23	824	3,522	0	0	0	0
2020-17	Aungmyin (Gangaw) – Aika Road	0	0	0	0	0	0	0	0	0
2020-18	Natt Chaung – Waibula – Bar Road	2	0	2	49	79	0	0	0	0
2019-02	Mindat – Matupi Road	2	0	2	49	79	0	0	0	0
2019-03	Shwebo – Ye-U Road	5	1	6	220	369	0	0	0	0
2019-04	Ye-U – Kalaywa Road	14	3	14	855	1,785	6	1	7	198
2019-06	Bellin – Yeywer – Pyinoolwin Road	10	0	10	37	201	8	0	8	165
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	4	0	4	40	95	1	0	1	18
2019-08	Dala – Letkokkon Road	3	2	5	151	288	0	2	2	227
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	5	0	5	46	122	1	0	1	21
2019-10	Tatkon – Expressway Link Road	5	0	3	55	89	0	0	0	0
2019-12	Labo – Mingin – Myoma Road	2	3	5	183	463	2	3	5	463
MP-01	Thaton – Eindu – Kawkareik – Myawaddy Road	6	8	14	366	1,096	0	1	1	366
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	89	16	105	1,101	6,212	60	8	68	4,086
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	11	1	12	152	497	0	0	0	0
MP-07	Shwebo – Myitkyina Road	36	10	46	142	1,901	0	0	0	0
MP-09	Monywa – Pathein Road	30	19	49	957	4,818	7	8	15	1,533
MP-11	Monywa – Yargyi – Kalewa Road	14	5	19	1,442	2,131	2	0	2	43
MP-21	Ann – Kyaukpyu Road	12	10	22	824	2,881	1	0	1	31
Total		**347**	**122**	**464**	**10,390**	**34,921**	**121**	**37**	**158**	**10,149**

Source: DOH

The necessity of bridge improvement is concentrated on the specific road sections as shown in **Figure 7.8**. For example, 97% of bridges on the section 2020-01 and 85% of bridges on the section 2020-02 need to be improved. More than 50% of bridges on 6 long-listed road sections (2020-01, 2020-02, 2020-07, 2019-06, 2019-12 and MP-08) need to be improved. However, these numbers include uncertainty of allowable loads for specific bridges due to unavailability of the data.



Source: DOH

Figure 7.8 Current Bridge Conditions of Long-Listed Road Sections

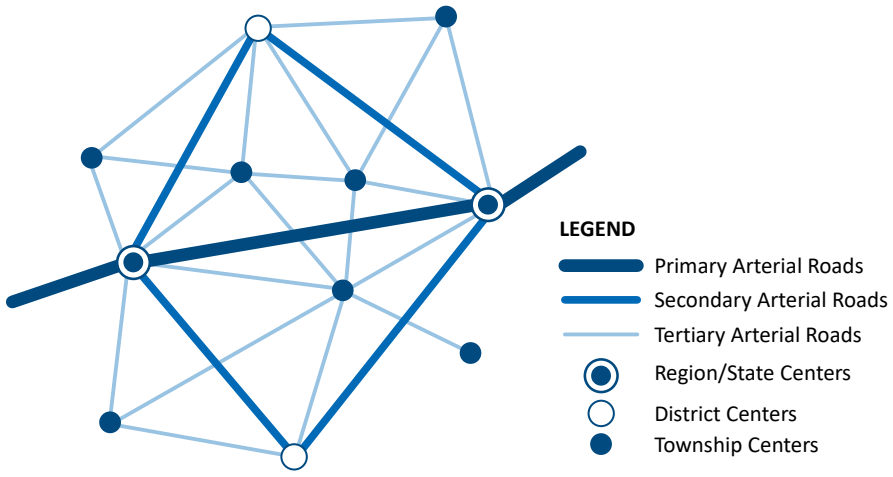
(5) Hierarchy of Road Function

In order to evaluate the importance of each road section, this Study prepared a functional road classification map as shown in **Figure 7.10** based on the definition shown in **Table 7.10**. Higher functionality should be given high-priority so that efficient road network development can be achieved.

Table 7.10 Definition of Functional Road Classification

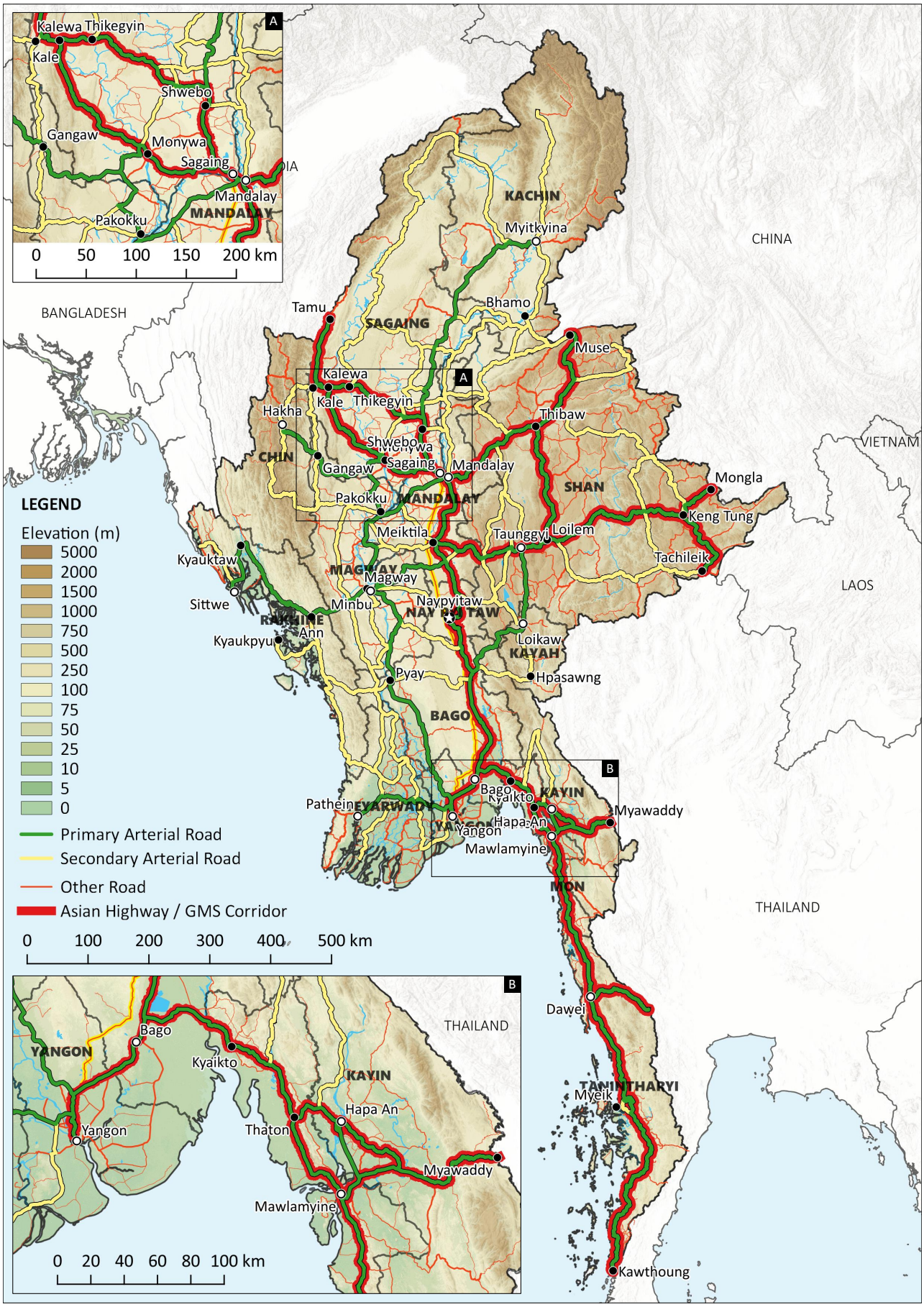
Classification	Function
Primary Arterial Roads	• Asian Highways and GMS corridors • Main road connect between two Region/State centers
Secondary Arterial Roads	• Main road connect between a Region/State center and a District center • Main road connect between two District centers
Tertiary Arterial Roads	• Main road connect between a District center and a Town center • Main road connect between two Town centers
Other Roads	• Main road connect between a Town center and a Village center • Main road connect between two Village centers

Source: JICA Study Team



Source: JICA Study Team

Figure 7.9 Conceptual Image of Functional Road Classification



Source: JICA Study Team

Figure 7.10 Proposed Functional Road Classification

The long-listed road sections fall into each functional road classification respectively as shown in **Table 7.11**.

Table 7.11 Road Classification of Long-Listed Road Sections

No.	Name of Road Sections	Road Classification		
		Primary	Secondary	Tertiary
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road			✓
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road			✓
2020-03 2019-05	Thickegyin – Paungbyin – Homalin – Hkamti Road		✓	
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road			✓
2020-07	Lapatan – Moenyo – Nattalin Road			✓
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)		✓	
2020-09	Minbu – Ann Road (Magway Section)	✓		
2020-10	Gangaw – Kalay Road		✓	
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road			✓
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	✓		
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)			✓
2020-14	Pyi – Taungup Road		✓	
2020-15	Taungup – Thandwe Road		✓	
2020-16	Taungup – Maei – Kyaukpyu Road		✓	
2020-17 2019-01	Aungmyin (Gangaw) – Aika Road			✓
2020-18	Natt Chaung – Waibula – Bar Road			✓
2020-19	Thanlwin Bridge (Hpa-An)	✓		
2019-02	Mindat – Matupi Road		✓	
2019-03	Shwebo – Ye-U Road	✓		
2019-04	Ye-U – Kalaywa Road	✓		
2019-06	Bellin – Yeywer – Pyinoolwin Road			✓
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)			✓
2019-08	Dala – Letkokkon Road			✓
2019-09	Kungyangon – Tawkayan – WestBoatDin Road		✓	
2019-10	Tatkon – Expressway Link Road		✓	
2019-12	Labo – Mingin – Myoma Road			✓
MP-01	Thaton – Eindu – Kawkareik – Myawaddy Road	✓		
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	✓		
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	✓		
MP-07	Shwebo – Myitkyina Road	✓		
MP-09	Monywa – Pathein Road		✓	
MP-11	Monywa – Yargyi – Kalewa Road	✓		
MP-13	Hinthada Bridge		✓	
MP-16	Hlaing River Bridge			✓
MP-18	Thetkal Thoung Bridge		✓	
MP-21	Ann – Kyaukpyu Road		✓	

Source: JICA Study Team

(6) Natural Disaster Risk

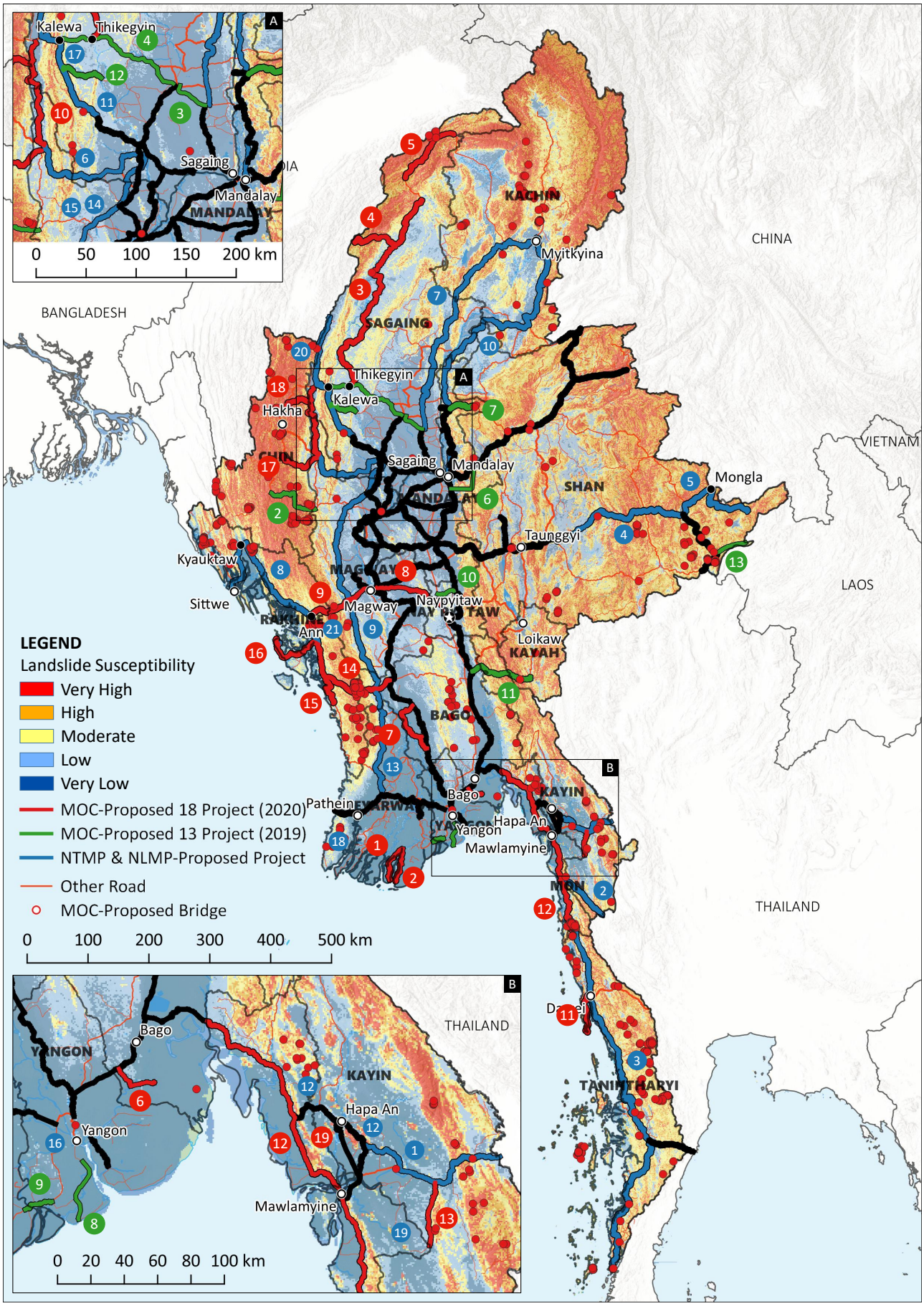
As described in Chapter 5, the land of Myanmar is susceptible to natural hazards such as cyclone and earthquake and it cause catastrophic devastation such as landslide and flooding. In view of building disaster-resilient road network, the road sections in disaster-prone areas should be prepared for mitigating such disasters.

Figure 7.11, **Figure 7.12** and **Figure 7.13** show disaster prone areas and the locations of the long-listed road sections. Based on these figures, the risk of natural disaster along the long-listed road sections can be summarized as shown in **Table 7.12**.

Table 7.12 Natural Disaster Risk of Long-Listed Road Sections

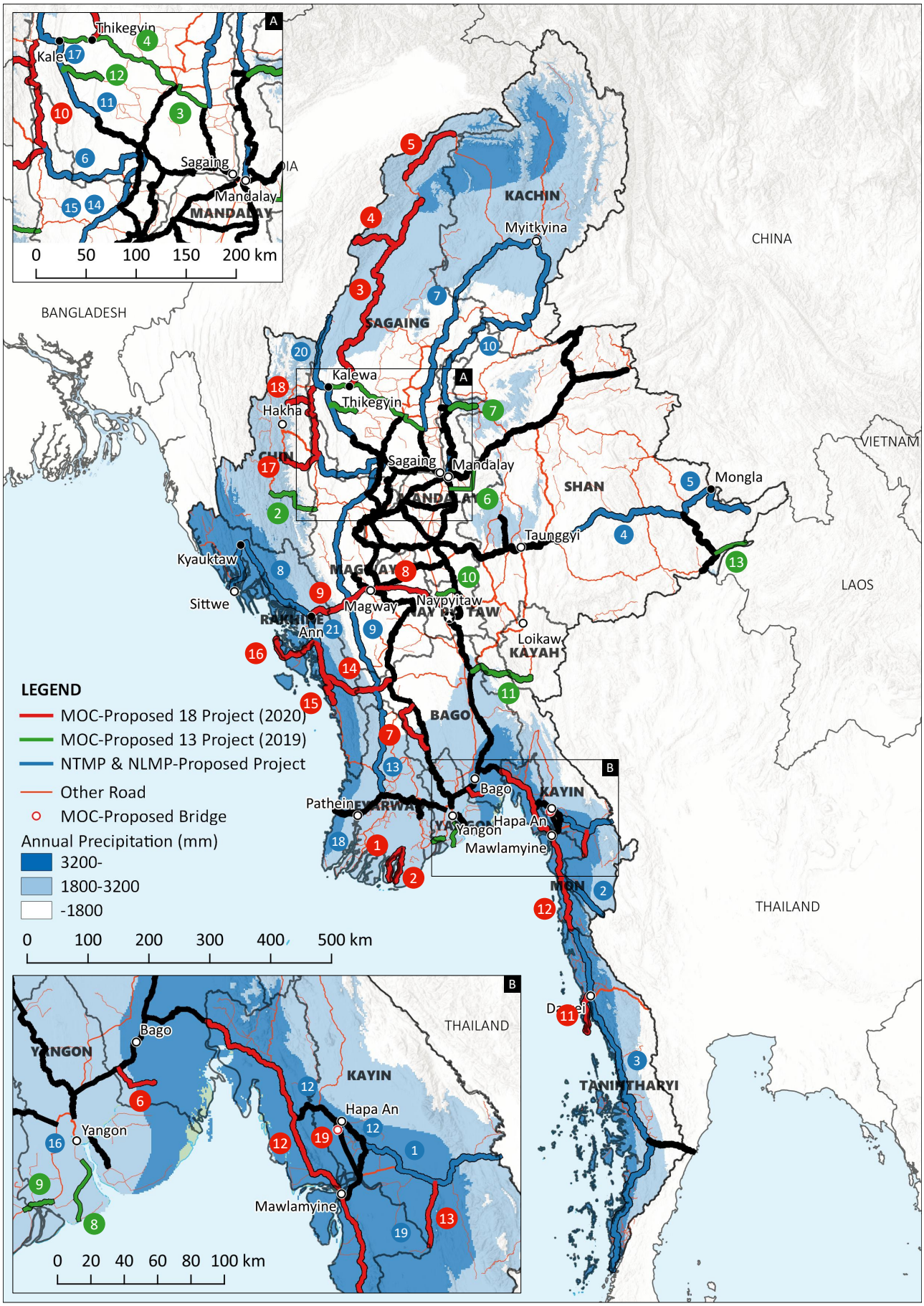
No.	Name of Road Sections	Natural Disaster Risk	
		Landslides	Flood
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road		✓
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road		✓
2020-03 2019-05	Thickegyin – Paungbyin – Homalin – Hkamti Road	✓	
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road		✓
2020-07	Lapatan – Moenyo – Nattalin Road		✓
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)		
2020-09	Minbu – Ann Road (Magway Section)	✓	
2020-10	Gangaw – Kalay Road		
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road		✓
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)		✓
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	✓	
2020-14	Pyi – Taungup Road	✓	
2020-15	Taungup – Thandwe Road		✓
2020-16	Taungup – Maei – Kyaukpyu Road		✓
2020-17 2019-01	Aungmyin (Gangaw) – Aika Road	✓	
2020-18	Natt Chaung – Waibula – Bar Road	✓	
2020-19	Thanlwin Bridge (Hpa-An)		
2019-02	Mindat – Matupi Road	✓	
2019-03	Shwebo – Ye-U Road		
2019-04	Ye-U – Kalaywa Road		
2019-06	Bellin – Yeywer – Pyinoolwin Road		
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)		
2019-08	Dala – Letkokkon Road		✓
2019-09	Kungyangon – Tawkayan – WestBoatDin Road		✓
2019-10	Tatkon – Expressway Link Road		
2019-12	Labo – Mingin – Myoma Road		
MP-01	Thaton – Eindu – Kawkareik – Myawaddy Road		
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road		
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road		
MP-07	Shwebo – Myitkyina Road		
MP-09	Monywa – Pathein Road		
MP-11	Monywa – Yargyi – Kalewa Road		
MP-13	Hinthada Bridge		✓
MP-16	Hlaing River Bridge		
MP-18	Thetkal Thoung Bridge		✓
MP-21	Ann – Kyaukpyu Road		✓

Source: JICA Study Team



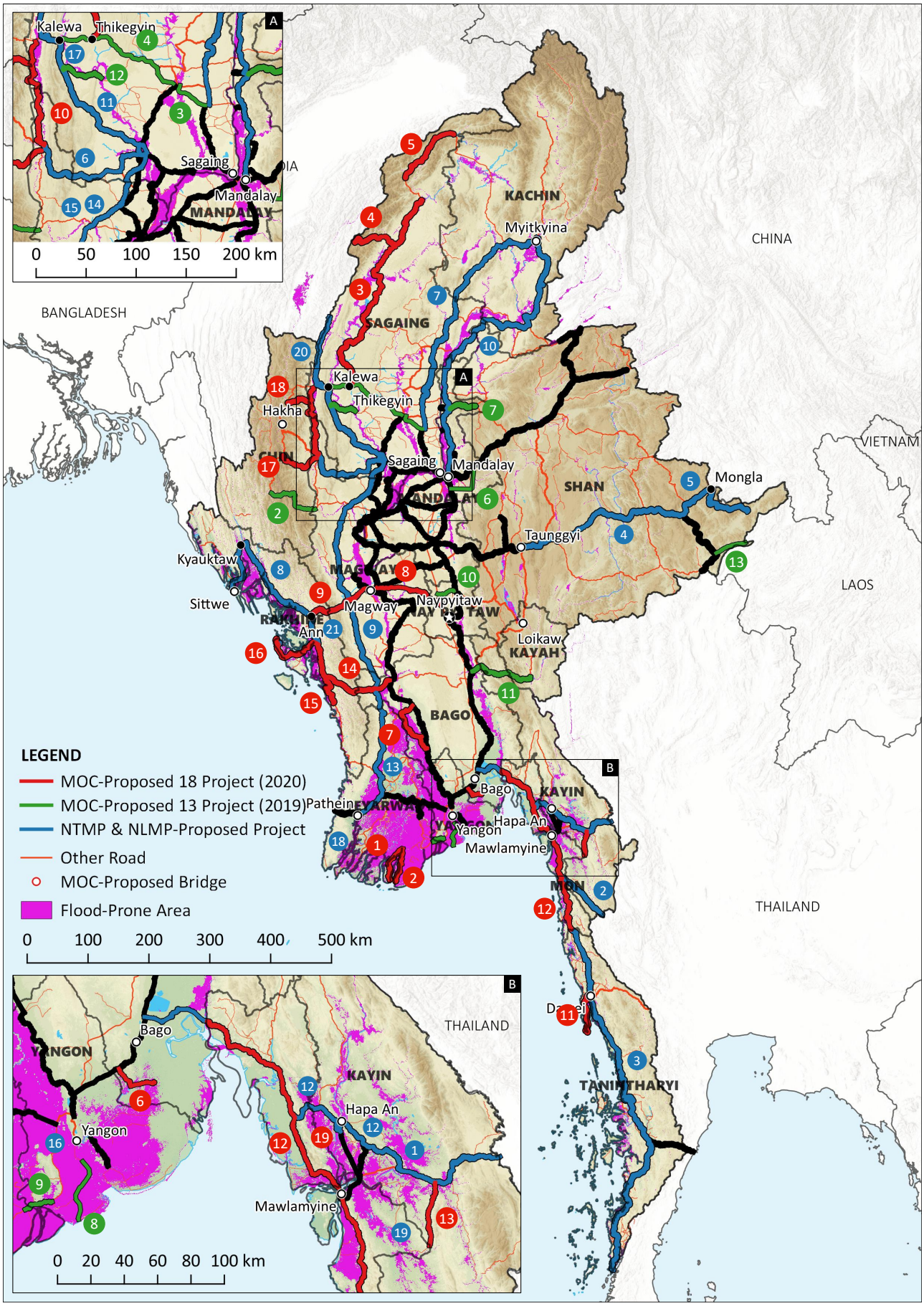
Source: JICA Study Team

Figure 7.11 Disaster-Prone Areas (Landslide Susceptibility)



Source: JICA Study Team

Figure 7.12 Disaster-Prone Areas (Heavy Rainfall)



Source: JICA Study Team

Figure 7.13 Disaster-Prone Areas (Flood)

(7) Necessity of Improvements

Based on the analysis of the present situation of the long-listed road sections, the section length and the number of bridge of each road section necessary for improvement is summarized in Table 7.13 and Table 7.14 respectively.

As mentioned earlier, high-priority should be given to the high-functional roads so that these tables are structured for each road classification.

Table 7.13 Necessity of Road Improvements

No.	Name of Road Sections	Necessity of Improvement (km)				Disaster Risk
		Pavement Type	Condition	Width	Overall	
Primary Arterial Roads						
2020-09	Minbu – Ann Road (Magway Section)	0.0	5.7	0.0	5.7	Landslide
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	0.0	15.8	0.0	15.8	Flood
2019-03	Shwebo – Ye-U Road	0.0	8.8	23.0	23.0	-
2019-04	Ye-U – Kalaywa Road	14.5	23.0	93.2	93.2	-
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	1.2	71.4	10.2	71.4	-
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	0.0	28.8	20.2	28.8	-
MP-07	Shwebo – Myitkyina Road	0.0	39.3	0.0	39.3	-
	Subtotal	**15.7**	**192.8**	**146.6**	**277.2**	
Secondary Arterial Roads						
2020-03 2019-05	Thickegyin – Paungbyin – Homalin – Hkamti Road	479.4	80.1	482.4	482.4	Landslide
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	0.0	0.1	9.8	9.8	-
2020-10	Gangaw – Kalay Road	0.0	5.2	0.0	5.2	-
2020-14	Pyi – Taungup Road	0.0	25.1	79.1	79.1	Landslide
2020-15	Taungup – Thandwe Road	0.0	8.4	28.7	28.7	Flood
2020-16	Taungup – Maei – Kyaukpyu Road	0.0	37.6	70.7	70.7	Flood
2019-02	Mindat – Matupi Road	0.0	50.9	159.5	159.5	Landslide
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	0.0	1.0	12.1	12.1	Flood
MP-09	Monywa – Pathein Road	0.0	0.0	18.7	18.7	-
MP-21	Ann – Kyaukpyu Road	0.0	81.7	79.3	81.7	Flood
	Subtotal	**479.4**	**290.1**	**940.3**	**947.9**	
Tertiary Arterial Roads						
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	51.2	0.0	67.6	67.6	Flood
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	42.7	0.0	29.2	42.7	Flood
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	0.0	2.6	2.0	2.6	Flood
2020-07	Lapatan – Moenyo – Nattalin Road	46.1	19.2	106.4	106.4	Flood
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	0.0	0.0	24.2	24.2	Flood
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	0.0	16.8	0.0	16.8	Landslide
2020-17 2019-01	Aungmyin (Gangaw) – Aika Road	77.1	38.4	94.5	94.5	Landslide
2020-18	Natt Chaung – Waibula – Bar Road	55.1	21.8	62.8	62.8	Landslide
2019-06	Bellin – Yeywer – Pyinoolwin Road	29.4	29.8	43.5	43.5	-
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	0.0	12.1	0.0	12.1	-
2019-08	Dala – Letkokkon Road	0.0	3.3	28.4	28.4	Flood
2019-12	Labo – Mingin – Myoma Road	0.0	3.2	37.0	37.0	-
	Subtotal	**301.6**	**147.2**	**495.6**	**538.6**	
Total		**796.7**	**630.1**	**1,582.5**	**1,763.7**	

Source: JICA Study Team

75% of the bridges required for improvement are medium-length bridge with its bridge length at 15-55 m and the remaining 25% are long-length bridges over 55 m.

Thanlwin Bridge (Hpa-An) is a proposed new bridge as a reconstruction of the existing steel truss bridge (L=540m) over Thanlwin River located on Thaton-Eindu-Kawkareik-Myawaddy Road.

Thanbyuzayat – Dawei – Myeik – Kawthonng Road (MP-03) has the biggest number of bridges (68 bridges) required for improvement because this road section passes through the Malay Peninsula and several rivers cross with this road. But this number of bridge would not be so accurate because this is due to the uncertainty of allowable load of 43 bridges (allowable loads of them are not available in the bridge inventory).

Table 7.14 Necessity of Bridge Improvements

No.	Name of Road Sections	Necessity of Improvement				Disaster Risk
		15-55m	55m-	Total	Bridge Length (m)	
Primary Arterial Roads						
2020-19	Thanlwin Bridge (Hpa-An) **[Proposed New Bridge]**	0	1	1	2,252	-
2019-04	Ye-U – Kalaywa Road	6	1	7	198	-
MP-01	Thaton – Eindu – Kawkareik – Myawaddy Road	0	1	1	366	-
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	60	8	68	4,086	-
MP-11	Monywa – Yargyi – Kalewa Road	2	0	2	43	-
	Subtotal	**68**	**11**	**79**	**6,945**	
Secondary Arterial Roads						
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	1	0	1	21	Flood
MP-09	Monywa – Pathein Road	7	8	15	1,533	-
MP-13	Hinthada Bridge **[Proposed New Bridge]**	0	1	1	3,620	Flood
MP-18	Thetkal Thoung Bridge **[Proposed New Bridge]**	0	1	1	760	Flood
MP-21	Ann – Kyaukpyu Road	1	0	1	31	Flood
	Subtotal	**9**	**10**	**19**	**5,965**	
Tertiary Arterial Roads						
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	23	8	31	1,818	Flood
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	9	3	12	735	Flood
2020-07	Lapatan – Moenyo – Nattalin Road	1	3	4	445	Flood
2019-06	Bellin – Yeywer – Pyinoolwin Road	8	0	8	165	-
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	1	0	1	18	-
2019-08	Dala – Letkokkon Road	0	2	2	227	Flood
2019-12	Labo – Mingin – Myoma Road	2	3	5	463	-
MP-16	Hlaing River Bridge **[Proposed New Bridge]**	0	1	1	1,200	-
	Subtotal	**44**	**20**	**64**	**5,071**	
Total		**121**	**41**	**162**	**17,981**	

Source: JICA Study Team

7.6 Second Evaluation for Preparation of Project Short-List

7.6.1 Evaluation Method

Table 7.15 shows the evaluation criteria and its weights for prioritization of road development needs based on the above development policy.

Table 7.15 Evaluation Criteria

1st Level Criteria	2nd Level Criteria	3rd Level Criteria	Evaluation Item	Weight
Economic criteria	Resilience	Disaster-resilience	Natural Disaster Risk	20%
		Impact to poverty reduction	Accessibility to Villages	20%
Basic need criteria	Poverty reduction	Impact to regional economy	Population Density (per km^2)	30%
			Poverty Headcount (%)	30%

Source: JICA Study Team

Table 7.16 shows the point allocation for each evaluation criteria.

Table 7.16 Point Allocation for Evaluation Criteria

Evaluation Item	Unit	Point				
		1	2	3	4	5
Natural Disaster Risk	Disaster Type	No Major Risk	-	Flood Risk	-	Landslide Risk
Accessibility to Villages		-	-	Moderate	Hard	Hardest
Population Density	Population/km^2	0-49	50-99	100-149	150-199	200-
Poverty Headcount	%	0%	20%	30%	40%	50%

Source: JICA Study Team

Natural Disaster Risk

The main purpose of the next project is to build a disaster-resilient road network and the landslide and flood risks are the major natural disasters with which road sector can deal. The road network in Myanmar especially within the mountainous areas is relatively in poor condition than other areas so that landslide risk were considered the highest priority under this evaluation item.

Accessibility to Villages

Low-accessibility to villages is one of the major issue in Myanmar whereas about two-thirds of rural people are physically isolated during part or all of the year. In order to examine the extent of accessibility to villages, this Study referred the open database “Hard to Reach Villages” of Myanmar Information Management Unit (MIMU), which classifies the level of hardness by “Moderate”, “Hard” and “Hardest”.

Population Density

Population densities per State/Region around the road sections were referred from the 2014 Population Census in Myanmar. If a road section passes through multiple states/regions, the average population density was calculated.

Table 7.17 Total Population and Population Density, 2014

	Area (km^2)	Total Population	Population Density per km^2
Kachin	676,577	51,486,253	76.1
Kayah	11,732	286,627	24.4
Kayin	30,383	1,574,079	51.8
Chin	36,019	478,801	13.3
Sagaing	93,702	5,325,347	56.8
Tanintharyi	43,345	1,408,401	32.5
Bago	39,404	4,867,373	123.5
Magway	44,821	3,917,055	87.4
Mandalay	30,888	6,165,723	199.6
Mon	12,297	2,054,393	167.1
Rakhine	36,778	3,188,807	86.7
Yangon	10,277	7,360,703	716.2
Shan	155,801	5,824,432	37.4
Ayeyarwady	35,032	6,184,829	176.5
Nay Pyi Taw	7,057	1,160,242	164.4

Source: Department of Population. 2017. Census Atlas Myanmar

Poverty Headcount

Poverty headcount was utilized for an indicator to measure the level of poverty by different states/regions surveyed by the World Bank-supported Myanmar Living Conditions Survey 2017.

Table 7.18 Poverty Measures, Number of Poor and Share of Poor, 2017

	Share of total population (%)	Poverty headcount (%)	Number of poor (000)	Share of poor (%)	Poverty gap (%)	Poverty gap squared (%)
Kachin	3.3	36.6	570	4.8	10	3.7
Kayah	0.6	32	91	0.8	8.4	3.1
Kayin	2.8	24.2	325	2.8	4.1	1
Chin	1	58	275	2.3	18.7	8.1
Sagaing	10.3	30.7	1,499	12.8	6.4	2.1
Tanintharyi	2.8	13.2	175	1.5	2.5	0.9
Bago	10.1	17.4	830	7.1	3.8	1.1
Magway	7.5	35.6	1,268	10.8	7.6	2.4
Mandalay	11.8	13.2	741	6.3	2.3	0.6
Mon	3.6	19.2	329	2.8	4.2	1.5
Rakhine	5.7	41.6	1,114	9.5	7	1.7
Yangon	15	13.7	974	8.3	2.7	0.8
Shan	11.1	28.6	1,507	12.8	6.8	2.3
Ayeyarwady	12.2	31.7	1,831	15.6	6.3	1.9
Nay Pyi Taw	2.2	22.1	228	1.9	4.1	1.1

Source: World Bank. 2017. Myanmar Living Conditions Survey 2017 – Poverty Report

7.6.2 Result of Evaluation

Table 7.19 summarizes the result of evaluation.

Table 7.19 Evaluation Result

No.	Name of Project	Location	Natural Disaster Risk	Accessibility to Villages	Population Density (per km²)	Poverty Headcount (%)	Score
			20%	20%	30%	30%	100%
Primary Arterial Roads							
2020-09	Minbu – Ann Road (Magway Section)	MAG	5	0	2	3	2.50
2019-04	Ye-U – Kalaywa Road	SAG	1	3	2	3	2.30
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	MON	3	0	4	1	2.10
2019-03	Shwebo – Ye-U Road	SAG	1	0	2	3	1.70
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	SAG/MAG	1	0	2	3	1.70
MP-07	Shwebo – Myitkyina Road	SAG/KAC	1	0	1	3	1.40
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	TAN	1	0	2	1	1.10
Secondary Arterial Roads							
2019-02	Mindat – Matupi Road	CHI	5	5	1	5	3.80
2020-03	Thickegyin – Paungbyin – Homalin – Hkamti Road	SAG	5	4	2	3	3.30
2020-14	Pyi – Taungup Road	RAK	5	0	2	4	2.80
2020-15	Taungup – Thandwe Road	RAK	3	0	2	4	2.40
2020-16	Taungup – Maei – Kyaukpyu Road	RAK	3	0	2	4	2.40
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	YAN	3	0	5	1	2.40
MP-21	Ann – Kyaukpyu Road	RAK	3	0	2	4	2.40
2020-10	Gangaw – Kalay Road	MAG	1	3	2	3	2.30
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	MAG	1	0	2	3	1.70
MP-09	Monywa – Pathein Road	SAG/MAG /BAG/AYE	1	0	2	2	1.40
Tertiary Arterial Roads							
2020-17	Aungmyin (Gangaw) – Aika Road	CHI	5	5	1	5	3.80
2020-18	Natt Chaung – Waibula – Bar Road	CHI	5	5	1	5	3.80
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	AYE	3	0	4	3	2.70
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	AYE	3	0	4	3	2.70
2019-08	Dala – Letkokkon Road	YAN	3	0	5	1	2.40
2019-12	Labo – Mingin – Myoma Road	SAG	1	3	2	3	2.30
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	KYN	5	0	2	2	2.20
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	BAG	3	0	3	1	1.80
2020-07	Lapatan – Moenyo – Nattalin Road	BAG	3	0	3	1	1.80
2019-06	Bellin – Yeywer – Pyinoolwin Road	MAN	1	0	4	1	1.70
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	MAN	1	0	4	1	1.70
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	TAN	3	0	1	1	1.20
Total							

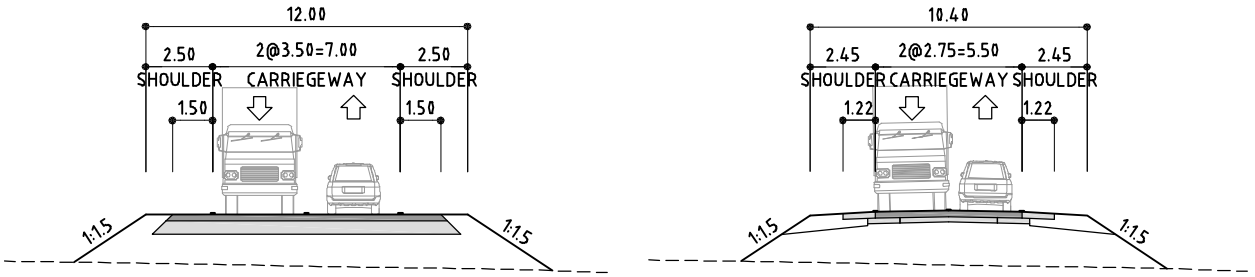
Source: JICA Study Team

7.6.3 Unit Cost of Road Improvement

(1) Basic Conditions of Cost Estimates

Carriageway (Pavement) Width

Although the MOC's design standard for lane width of arterial roads is 3.5 m (see **Figure 3.10**), this study considered 2.75 m of lane width is the minimum requirement for the arterial roads in Myanmar as the Regional Development for Poverty Reduction Project Phase I and Phase II also applied 2.75 m in order to maximize the length of road improvement under the limited budget. As mentioned earlier, the pavement width of 38% of the long-listed road sections are still narrower than 5.5 m (= 2.75 m x 2).



MOC's Design Standard for Main Arterial Road **Applied in Previous Projects**

Source: JICA Study Team, based on Road Design Criteria in Myanmar, DOH (MOC), 2015

Figure 7.14 Comparison of Typical Cross Sections

Pavement Type

This study considered that the penetration macadam pavement (low-cost pavement) would be the minimum requirement for the arterial roads in Myanmar since the Regional Development for Poverty Reduction Project Phase I and Phase II also applied this pavement type. However, the penetration macadam pavement does not have a durability against heavy vehicle traffic and it would be easily deteriorated by over-loaded vehicle traffic. The Phase II project had changed the pavement type from penetration macadam, which was originally planned in the Preparatory Survey, to Portland cement concrete pavement during its implementation stage for the relatively high-traffic demand road sections (see **Table 4.4**).

Due to COVID-19 restrictions, this study couldn't collect any traffic-related information/data on the long-listed road sections. Therefore, this study assumes that the Primary Arterial Roads would have high-traffic demand sufficient for the Portland cement concrete pavement and the Secondary Arterial Roads would have low-traffic demand sufficient for the penetration macadam pavement for cost estimation purpose. However, the pavement type should be re-examined during the design stage of this project.

Slope Protection

Stone masonry retaining wall and gabion wall with its maximum height of 3 to 5 m are commonly used for slope protections in Myanmar. Large-scale slope protections such as concrete crib works, rock bolts, soil nailing or ground anchor works described in Chapter 5 would not be capable by the local contractor in Myanmar. Therefore, this study considered that small-scale slope protection would only be applicable for the road improvement projects under local competitive bidding and large-scale slope protection projects should be separately formulated as international competitive bidding projects.

Flood Mitigation

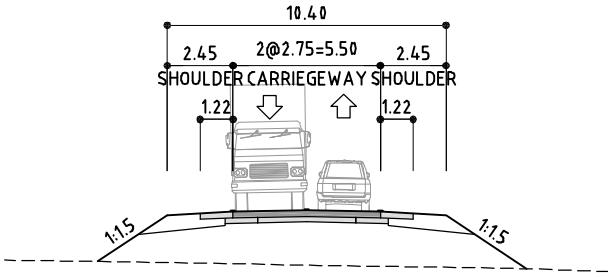
There are some road sections of the long-listed projects located in flood-prone areas. Due to the limited information and impossibility of site survey due to COVID-19, this study roughly estimate that 2.5 m-height of embankment would not be submerged even in flooding situation. Therefore, this additional volume of embankment fill is considered for the cost estimation.

(2) Unit Construction Costs

In reference to the cost estimates and bid results of the Regional Development for Poverty Reduction Project Phase I and Phase II, the unit costs of road improvement per linear km (local contractor based cost) were estimated as follows (for more details, see **Table 7.20** - **Table 7.24**):

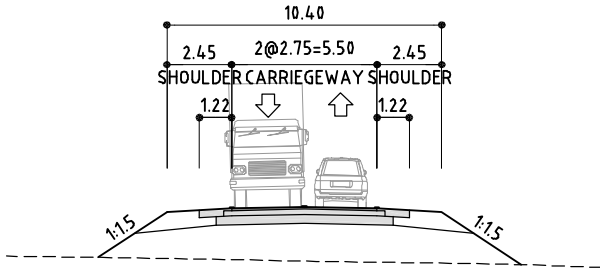
- Construction of Portland Cement Concrete Road (Flat Area): 500 million Kyat/km
- Construction of Penetration Macadam Pavement Road (Flat Area): 370 million Kyat/km
- Construction of Portland Cement Concrete Road (Mountainous Area): 730 million Kyat/km
- Construction of Penetration Macadam Pavement Road (Mountainous Area): 540 million Kyat/km
- Construction of Portland Cement Concrete Road (Flood-Plain): 900 million Kyat/km

Table 7.20 Construction Cost of PCCP Road (Flat Area)

Portland Cement Concrete Road (Flat Area)				
				
Item	**Unit**	**Quantity**	**Unit Cost (Kyat)**	**Cost (Kyat)**
Portland Cement Concrete Surface Course (200 mm)	sq.m	5,500	40,000	220,000,000
Crushed Rock Subbase Course (200 mm)	cu.m	1,220	65,000	79,300,000
Gravelly Soil Hard Shoulder (200 mm)	cu.m	550	15,000	8,250,000
Subgrade Preparation	sq.m	12,500	1,250	15,625,000
Embankment Fill	cu.m	10,000	5,000	50,000,000
Reinforced Concrete Pipe Culvert (ϕ610 mm)	l.m	150	100,000	15,000,000
Reinforced Concrete Box Culvert (1.5m x 1.5m)	l.m	30	2,200,000	66,000,000
Miscellaneous Structures	l.s	1	25,000,000	25,000,000
Other Indirect Costs (5% of above)	l.s	1	24,000,000	24,000,000
Total Cost				503,175,000
Total Cost (Rounded)				**500,000,000**

Source: JICA Study Team

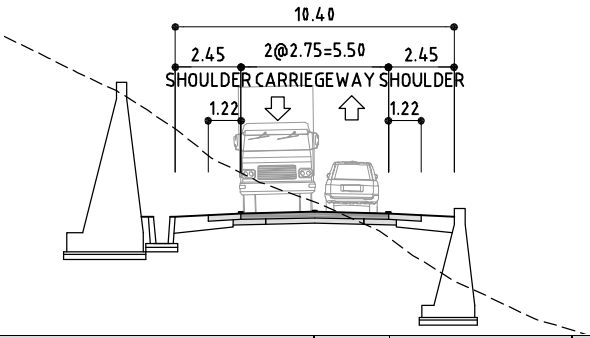
Table 7.21 Construction Cost of PMP Road (Flat Area)

Penetration Macadam Pavement Road (Flat Area)				
				
Item	**Unit**	**Quantity**	**Unit Cost (Kyat)**	**Cost (Kyat)**
Penetration Macadam Surface Course (75mm)	sq.m	5,500	15,000	82,500,000
Crushed Rock Base Course (200 mm)	cu.m	1,220	65,000	79,300,000
Crushed Rock Subbase Course (350 mm)	cu.m	2,345	45,000	105,525,000
Gravelly Soil Hard Shoulder (200 mm)	sq.m	550	15,000	8,250,000
Subgrade Preparation	sq.m	12,500	1,250	15,625,000
Embankment Fill	cu.m	2,500	5,000	12,500,000
Reinforced Concrete Pipe Culvert (ϕ610 mm)	l.m	75	100,000	7,500,000
Reinforced Concrete Box Culvert (1.5m x 1.5m)	l.m	15	2,200,000	33,000,000
Miscellaneous Structures	l.s	1	10,000,000	10,000,000
Other Indirect Costs (5% of above)	l.s	1	17,700,000	17,700,000
Total Cost				371,900,000
Total Cost (Rounded)				**370,000,000**

Source: JICA Study Team

Table 7.22 Construction Cost of PCCP Road (Mountainous Area)

Portland Cement Concrete Road (Mountainous Area)

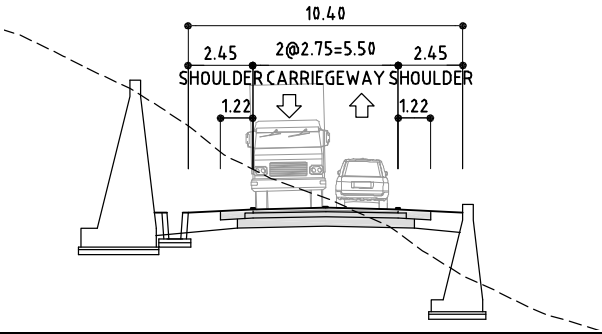


Item	Unit	Quantity	Unit Cost (Kyat)	Cost (Kyat)
Portland Cement Concrete Surface Course (200 mm)	sq.m	5,500	40,000	220,000,000
Crushed Rock Subbase Course (200 mm)	cu.m	1,220	65,000	79,300,000
Gravelly Soil Hard Shoulder (200 mm)	cu.m	550	15,000	8,250,000
Subgrade Preparation	sq.m	12,500	1,250	15,625,000
Embankment Fill	cu.m	10,000	5,000	50,000,000
Reinforced Concrete Pipe Culvert (ϕ610 mm)	l.m	150	100,000	15,000,000
Reinforced Concrete Box Culvert (1.5m x 1.5m)	l.m	30	2,200,000	66,000,000
Stone Masonry (Retaining Wall)	cu.m	1,900	90,000	171,000,000
Side Ditch	l.m	1,000	45,000	45,000,000
Miscellaneous Structures	l.s	1	25,000,000	25,000,000
Other Indirect Costs (5% of above)	l.s	1	32,100,000	32,100,000
Total Cost				729,975,000
Total Cost (Rounded)				**730,000,000**

Source: JICA Study Team

Table 7.23 Construction Cost of PMP Road (Mountainous Area)

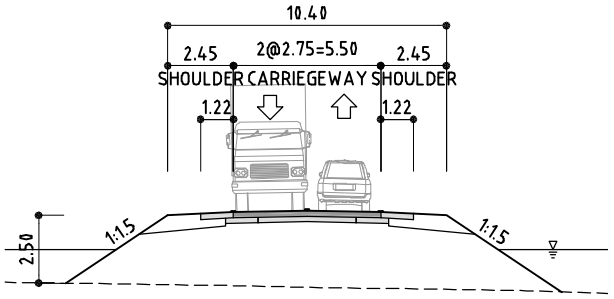
Penetration Macadam Pavement Road (Mountainous Area)



Item	Unit	Quantity	Unit Cost (Kyat)	Cost (Kyat)
Penetration Macadam Surface Course (75mm)	sq.m	5,500	15,000	82,500,000
Crushed Rock Base Course (200 mm)	cu.m	1,220	65,000	79,300,000
Glanular Subbase Course (350 mm)	cu.m	2,345	45,000	105,525,000
Gravelly Soil Hard Shoulder (200 mm)	sq.m	550	15,000	8,250,000
Subgrade Preparation	sq.m	12,500	1,250	15,625,000
Embankment Fill	cu.m	2,500	5,000	12,500,000
Reinforced Concrete Pipe Culvert (ϕ610 mm)	l.m	75	100,000	7,500,000
Reinforced Concrete Box Culvert (1.5m x 1.5m)	l.m	15	2,200,000	33,000,000
Stone Masonry (Retaining Wall)	cu.m	1300	90,000	117,000,000
Side Ditch	l.m	1000	45,000	45,000,000
Miscellaneous Structures	l.s	1	10,000,000	10,000,000
Other Indirect Costs (5% of above)	l.s	1	25,800,000	25,800,000
Total Cost				542,000,000
Total Cost (Rounded)				**540,000,000**

Source: JICA Study Team

Table 7.24 Construction Cost of PCCP Road (Flood-Plain)

Portland Cement Concrete Road (Flood-Plain)				
				
Item	**Unit**	**Quantity**	**Unit Cost (Kyat)**	**Cost (Kyat)**
Portland Cement Concrete Surface Course (200 mm)	sq.m	5,500	40,000	220,000,000
Crushed Rock Subbase Course (200 mm)	cu.m	1,220	65,000	79,300,000
Gravelly Soil Hard Shoulder (200 mm)	cu.m	550	15,000	8,250,000
Subgrade Preparation	sq.m	12,500	1,250	15,625,000
Embankment Fill	cu.m	30,000	5,000	150,000,000
Reinforced Concrete Pipe Culvert (ϕ610 mm)	l.m	300	100,000	30,000,000
Reinforced Concrete Box Culvert (1.5m x 1.5m)	l.m	150	2,200,000	330,000,000
Miscellaneous Structures	l.s	1	25,000,000	25,000,000
Other Indirect Costs (5% of above)	l.s	1	42,900,000	42,900,000
Total Cost				901,075,000
Total Cost (Rounded)				**900,000,000**

Source: JICA Study Team

(3) Cost for Possible Countermeasures against Landslides

Due to unavailability of the detailed site information, this Study estimated the cost for the following five (5) possible countermeasures against landslides utilizing Japanese technology based on assumptions of site conditions:

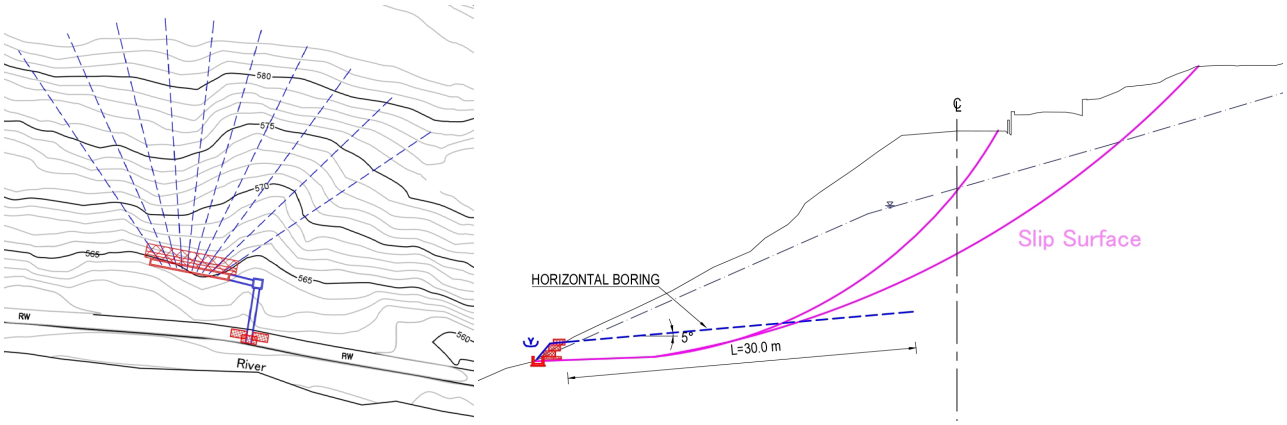
- Horizontal Drainage Boring: 15 million JPY / set.
- Spray Crib Works: 80 million JPY / 100 m
- Spray Crib Works with Rock Bolts: 250 million JPY / 100 m
- Ground Anchor Works: 766 million JPY / 100 m
- Light-weight Embankment with Air-mixed Mortar: 58 million JPY / 100 m

Horizontal Drainage Boring

Horizontal drainage boring should be placed at the location where collapse, slide, and gravity deformation are anticipated. For one landslide, usually one to several sets of horizontal drainage boring are planned. **Figure 7.15** shows a set of horizontal drainage boring planned at lower slope of a highway, which are affected by a movement of slides.

Multiple boreholes can be drilled by one drilling machine placed at one place and thus horizontal drainage boring is often planned in a fan shaped arrangement with a set of 10 to 12 boreholes for one location. The horizontal drainage boring should be drilled slightly upward with an upward inclination of 5 degrees from the horizon. Usually the length of borehole is 20 to 50 m. With a fan shaped arrangement, the end of each borehole has an intervals of around 5 m with a neighboring boreholes. After drilling, perforated casing pipes with a diameter of 50 to 100 mm are installed into boreholes. Outlet of perforated pipes should be protected with gabion or concrete retaining wall to prevent erosion of the ground, with drainage system to drain collected groundwater properly to outside of the landslide area.

The cost for horizontal drainage boring depends on the size, length, and number of boreholes as well as the type of drilling machine to be used and the topographic condition where drilling machines will be placed. The roughly estimated cost for a set of horizontal drainage boring (total 300 m) shown in **Figure 7.15** is about JPY 15 million / set.



Source: JICA Study Team

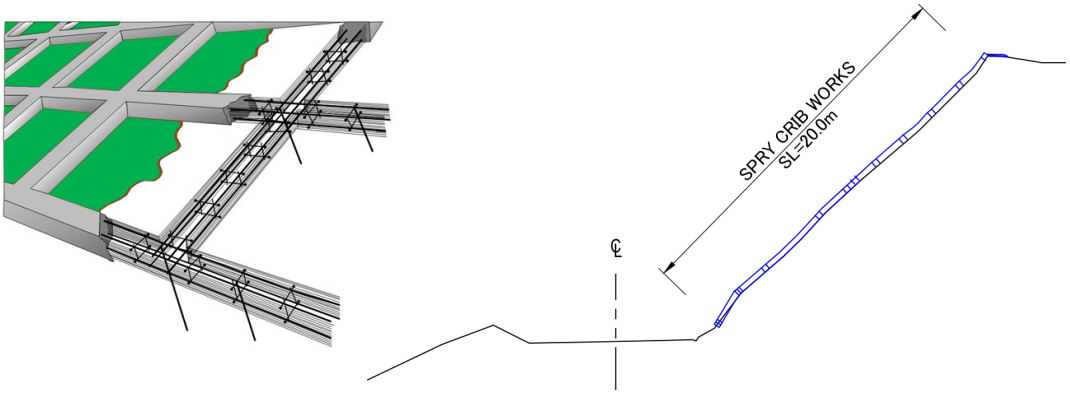
Figure 7.15 Example Plan and Profile of Horizontal Drainage Boring

Spray Crib Works

Spray crib works are versatile slope protection works which can be adopted both natural and artificial slopes. At the same time, spray crib works can be used individually as well as combination with rock bolts / ground anchor.

Spray crib works are applied to the surface of the slope which needs protection against negative conditions such as erosion/weathering. The area among the frames are usually covered by vegetation / stone pitching / shotcrete. Shotcrete is applied in case the surface of the slope needs to be totally covered, excluding the case where groundwater spring/seepage are anticipated.

In a usual civil work contract, spay crib works are paid in a unit of linear meter (lm). The roughly estimated cost for spray crib works with a slant length of 20 m as shown in **Figure 7.16** is about JPY 80 million / 100m.



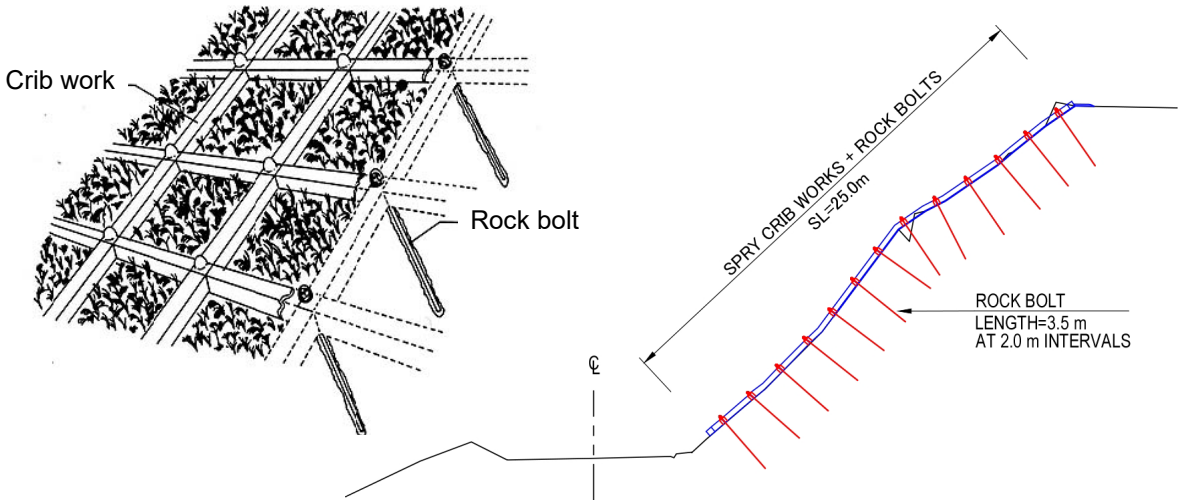
Source: JICA Study Team

Figure 7.16 Spray Crib Works

Spray Crib Works with Rock Bolts

Spray Crib Works are often applied with rock bolts, which increase shear strengths of the slope. Rock bolts are installed at the intersections of the frames of spray crib works.

In a usual civil work contract, rock bolts are paid in a unit of linear meter. The roughly estimated cost for spray crib works with a slant length of 25 m in combination with rock bolts of a length of 3.5 m installed at intervals of 2.0 m as shown in **Figure 7.17** is about JPY 250 million / 100m.



Source: JICA Study Team

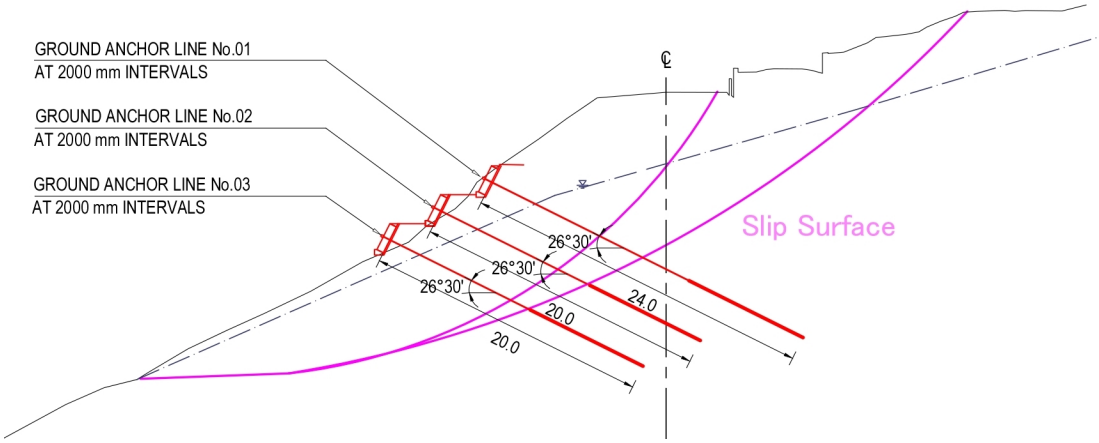
Figure 7.17 Spray Crib Works with Rock Bolts

Ground Anchor Works

Ground anchor is one of the prevention works to stabilize landslides or retain unstable slopes. In order to ensure the strong tensile force applied to the head of anchors, anchor pillows made of reinforced concrete or Fiber Reinforced Plastics (FRP) are used as bearing members placed on the slope surface.

Since ground anchor is relatively costly compared to spray crib works and rock bolts, the location and angle of ground anchor installation should be carefully examined. To save construction cost, ground anchor can be installed on limited lines (rows) carefully selected through slope stability analysis.

As an example, roughly estimated cost for three rows of ground anchor works at 2 m intervals shown in **Figure 7.18** is about JPY 766 million / 100m.



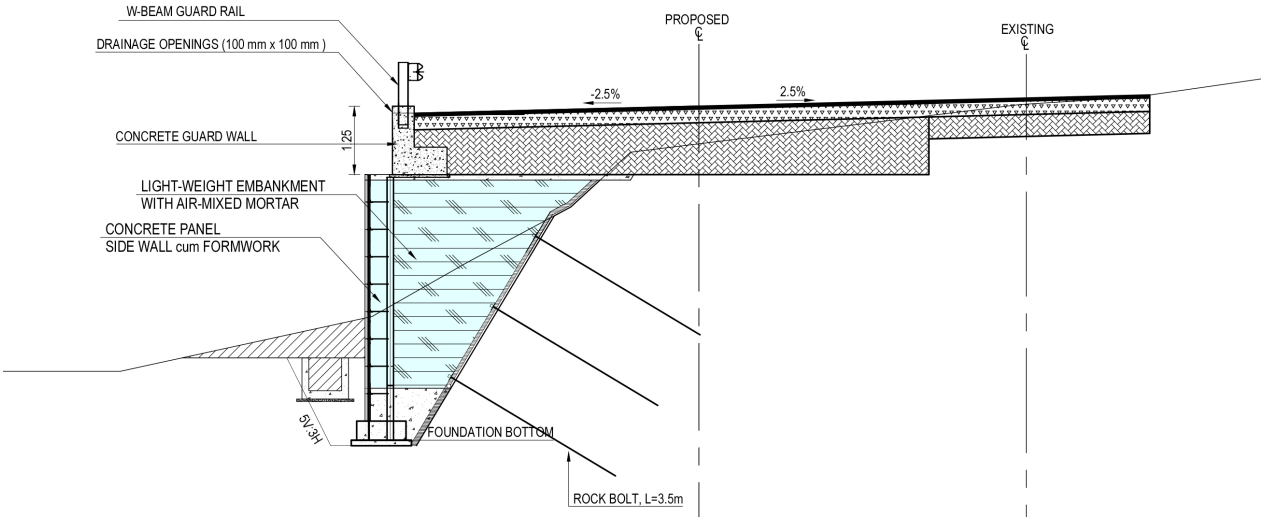
Source: JICA Study Team

Figure 7.18 Ground Anchor Works

Light-weight Embankment with Air-mixed Mortar

Light-weight embankment with air-mixed mortar is an effective method to restore damaged road bed as well as to widen the road width on steep hill slopes. Air-mixed mortar has fluidity to fill up embankment by following undulation of natural ground but requires formwork at the edge of embankment. Vertical walls of stacked concrete panels erected along the edge of embankment work as formwork as well as protection of the side of embankment of air-mixed mortar. Such vertical walls of concrete panels are widely used in Japan.

The roughly estimated cost for light-weight embankment with air-mixed mortar as shown in **Figure 7.19** is around JPY 58 million / 100m, having cross-section of 20 m^2 of the embankment.



Source: JICA Study Team

Figure 7.19 Light-weight Embankment with Air-mixed Mortar

Application of Countermeasures

The abovementioned countermeasures are usually planned in combination with other works. In other words, such countermeasures are rarely used separately; instead, a combination of multiple works is often planned to fulfil requirements. For example, horizontal drainage borings are planned along with soil removal and ground anchor works to secure a required design safety factor through slope stability analysis. Such combination is so designed to meet the requirement of each site in the aim of stabilizing slopes or preventing landslide activities.

7.6.4 Estimated Construction Cost

Based on the road inventories and the unit cost for road improvement, the road sections necessary for improvement and its construction cost was examined as summarized in **Table 7.25**.

Table 7.25 Estimated Construction Cost of Long-Listed Road Sections

No.	Name of Project	Km From	Km To	Length (km)	Unit Cost per km (Kyat million)	Construction Cost (Kyat million)
Primary Arterial Roads						
2020-09	Minbu – Ann Road (Magway Section)	29.4	51.1	21.7	730	15,841
2019-04	Ye-U – Kalaywa Road	1.6	17.7	16.1	500	8,050
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	307.4	321.8	14.4	900	12,960
2019-03	Shwebo – Ye-U Road	12.1	21.7	9.7	500	4,850
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	0.0	25.8	25.8	500	12,900
		43.5	52.3	8.8	500	4,400
MP-07	Shwebo – Myitkyina Road	6.4	16.5	10.1	500	5,050
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	670.5	684.0	13.5	500	6,750
		690.0	727.0	37.0	500	18,500
		746.9	753.1	6.2	500	3,100
		867.4	901.9	34.5	500	17,250
		933.0	982.9	49.9	500	24,950
	Subtotal			**272.8**		**157,191**
Secondary Arterial Roads						
2019-02	Mindat – Matupi Road	17.3	25.8	8.5	540	4,590
		66.0	112.7	46.7	540	25,218
		123.1	162.5	39.4	540	21,276
2020-03	Thickegyin – Paungbyin – Homalin – Hkamti Road	0.0	49.5	49.5	540	26,730
		49.5	99.0	49.5	540	26,730
		99.0	148.5	49.5	540	26,730
		148.5	198.0	49.5	540	26,730
		250.0	299.5	49.5	540	26,730
		299.5	349.0	49.5	540	26,730
2020-14	Pyi – Taungup Road	77.5	117.5	40.0	540	21,600
2020-15	Taungup – Thandwe Road	3.2	36.6	33.4	900	30,060
2020-16	Taungup – Maei – Kyaukpyu Road	22.4	66.2	43.8	900	39,420
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	11.3	18.3	7.0	900	6,300
MP-21	Ann – Kyaukpyu Road (Ann-Maei)	1.6	36.0	34.4	900	30,960
		36.0	67.0	31.0	900	27,900
2020-10	Gangaw – Kalay Road	0	0	0	370	0
2020-08	Taungnyo – Myothit – Kanpyar Road (Nay Pyi Taw Section)	26.8	36.6	9.8	370	3,626
MP-09	Monywa – Pathein Road	679.4	698.1	18.7	370	6,919
	Subtotal			**610.0**		**378,249**
Tertiary Arterial Roads						
2020-17	Aungmyin (Gangaw) – Aika Road	29.8	61.8	32.0	540	17,280
		61.8	93.8	32.0	540	17,280
		96.4	116.9	20.5	540	11,070
2020-18	Natt Chaung – Waibula – Bar Road	-	-	16.3	540	8,802
		-	-	38.8	540	20,952
2020-01	Bogalay – Kyeinchaung – Gadon Gani Road	-	-	33.8	900	30,420
		-	-	33.8	900	30,420
2020-02	Bogalay – Settsan – Htaw Paing – Amar Road	-	-	31.1	900	27,990
		-	-	31.1	900	27,990
2019-08	Dala – Letkokkon Road	26.0	57.9	31.9	900	28,710
2019-12	Labo – Mingin – Myoma Road	-	-	0	370	0
2020-13	Mudon – ChaungNaKwa – Maethayaw – Hlaingkwe (Kawkareik) Road (Maethayaw – Hlaingkwe Section)	13.0	52.5	39.5	540	21,330
2020-06	Intakaw – Htonegyi – Kawa – Ohnnae Road	-	-	0	370	0
2020-07	Lapatan – Moenyo – Nattalin Road	0	36.7	36.7	900	33,030
		36.7	73.5	36.8	900	33,120
		73.5	110.2	36.7	900	33,030
2019-06	Bellin – Yeywer – Pyinoolwin Road	13.0	43.5	30.5	370	11,285
2019-07	Mandalay – Mogok Road (Phawtaw – Mogok section)	150.5	173.5	23.0	370	8,510
2020-11	Kamyawkin – Launglon – Kyauknimaw – Shinmaw Road	-	-	24.2	900	21,780
	Subtotal			**529.0**		**382,999**
Total				**1,411.8**		**918,439**

Source: JICA Study Team

7.6.5 Selection of Priority Projects

As the result of evaluation, the following 14 road sections were selected from the higher priorities with its total construction cost is about 500 billion Kyat. Considering that the basis of the cost estimation under this Survey is very rough and there will be variation of cost if it will be reviewed based on the actual site conditions.

- 2020-09 Minbu – Ann Road (Magway Section)
- 2019-04 Ye-U – Kalaywa Road
- 2020-12 Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)
- 2019-03 Shwebo – Ye-U Road
- MP-06 Monywa - Pale - Gangaw – Kalaymyo Road
- MP-07 Shwebo – Myitkyina Road
- MP-03 Thanbyuzayat – Dawei – Myeik – Kawthonng Road
- 2019-02 Mindat – Matupi Road
- 2020-03 Thickegyin – Paungbyin – Homalin – Hkamti Road
- 2020-14 Pyi – Taungup Road
- 2020-15 Taungup – Thandwe Road
- 2020-16 Taungup – Maei – Kyaukpyu Road
- 2019-09 Kungyangon – Tawkayan – WestBoatDin Road
- MP-21 Ann – Kyaukpyu Road (Ann-Maei)

Table 7.26 Short List of Road Improvement Projects

No.	Name of Project	Km From	Km To	Length (km)	Unit Cost per km (Kyat million)	Construction Cost (Kyat million)	Accumulated Cost (Kyat million)
Primary Arterial Roads							
2020-09	Minbu – Ann Road (Magway Section)	29.4	51.1	21.7	730	15,841	15,841
2019-04	Ye-U – Kalaywa Road	1.6	17.7	16.1	500	8,050	23,891
2020-12	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)	307.4	321.8	14.4	900	12,960	36,851
2019-03	Shwebo – Ye-U Road	12.1	21.7	9.7	500	4,850	41,701
MP-06	Monywa - Pale - Gangaw – Kalaymyo Road	0.0	25.8	25.8	500	12,900	54,601
		43.5	52.3	8.8	500	4,400	59,001
MP-07	Shwebo – Myitkyina Road	6.4	16.5	10.1	500	5,050	64,051
MP-03	Thanbyuzayat – Dawei – Myeik – Kawthonng Road	670.5	684.0	13.5	500	6,750	70,801
		690.0	727.0	37.0	500	18,500	89,301
		746.9	753.1	6.2	500	3,100	92,401
		867.4	901.9	34.5	500	17,250	109,651
		933.0	982.9	49.9	500	24,950	134,601
Subtotal				**272.8**		**157,191**	
Secondary Arterial Roads							
2019-02	Mindat – Matupi Road	17.3	25.8	8.5	540	4,590	139,191
		66.0	112.7	46.7	540	25,218	164,409
		123.1	162.5	39.4	540	21,276	185,685
2020-03	Thickegyin – Paungbyin – Homalin – Hkamti Road	0.0	49.5	49.5	540	26,730	212,415
		49.5	99.0	49.5	540	26,730	239,145
		99.0	148.5	49.5	540	26,730	265,875
		148.5	198.0	49.5	540	26,730	292,605
		250.0	299.5	49.5	540	26,730	319,335
		299.5	349.0	49.5	540	26,730	346,065
2020-14	Pyi – Taungup Road	77.5	117.5	40.0	540	21,600	367,665
2020-15	Taungup – Thandwe Road	3.2	36.6	33.4	900	30,060	397,725
2020-16	Taungup – Maei – Kyaukpyu Road	22.4	66.2	43.8	900	39,420	437,145
2019-09	Kungyangon – Tawkayan – WestBoatDin Road	11.3	18.3	7.0	900	6,300	443,445
MP-21	Ann – Kyaukpyu Road (Ann-Maei)	1.6	36.0	34.4	900	30,960	474,405
		36.0	67.0	31.0	900	27,900	502,305
Subtotal				**581.2**		**367,704**	
Total				**854.0**		**524,895**	

Source: JICA Study Team

Source: JICA Study Team

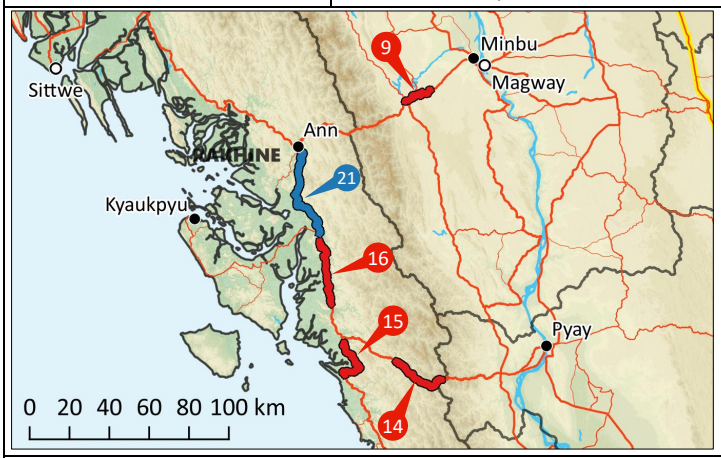
Figure 7.20 Shortlisted Priority Projects

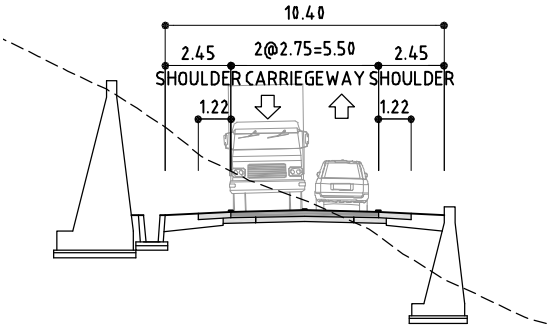
7.7 Profile of Priority Projects

(1) Road Improvement Projects

2020-09 Minbu – Ann Road (Magway Section)

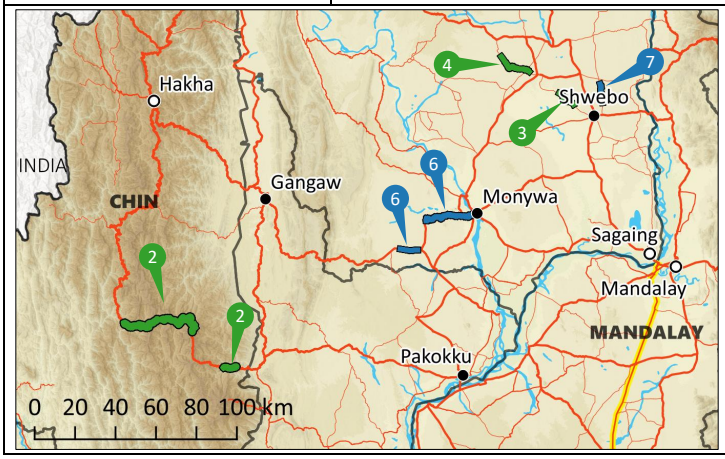
Reference No.	2020-09
Project Title	Minbu – Ann Road (Magway Section)
Location	Magway
Project Road Length	21.7 km
Road Classification	Primary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Portland Cement Concrete Pavement (W=5.5m)
Natural Disaster Risk	Landslide
Estimated Construction Cost	15,841 million Kyat

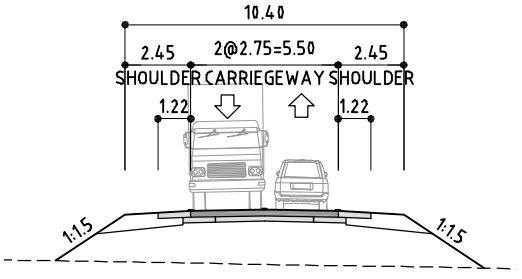




2019-04 Ye-U – Kalaywa Road

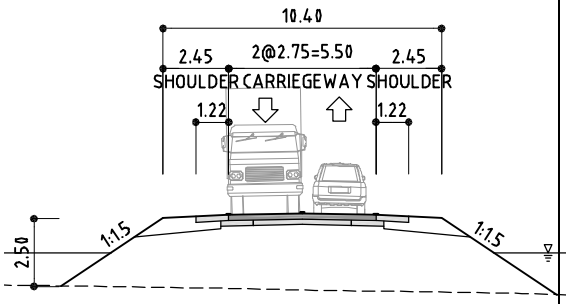
Reference No.	2019-04
Project Title	Ye-U – Kalaywa Road
Location	Sagaing
Project Road Length	16.1 km
Road Classification	Primary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Portland Cement Concrete Pavement (W=5.5m)
Natural Disaster Risk	None
Estimated Construction Cost	8,050 million Kyat





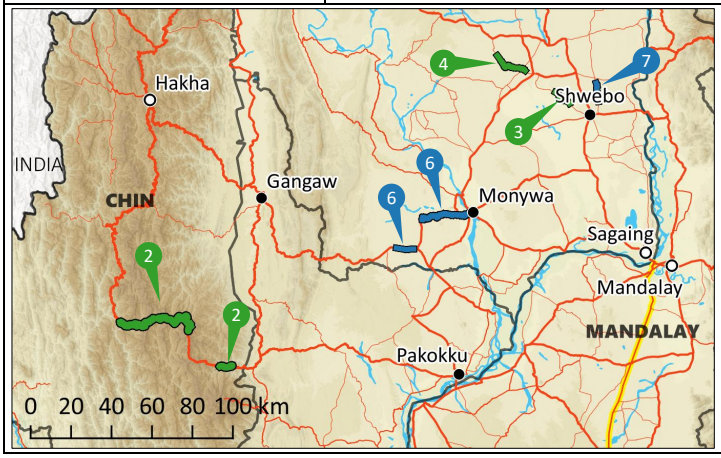
2020-12 Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)

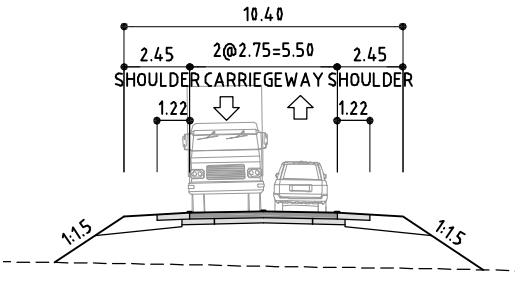
Reference No.	2020-12
Project Title	Payargyi – Mawlamyaing – Dawei – Myeik – Bokeyin – Kawthoung Road (mawlamyaing – Ye – Malawetaung)
Location	Mon
Project Road Length	39.57 km
Road Classification	Primary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Portland Cement Concrete Pavement (W=5.5m)
Natural Disaster Risk	Flood
Estimated Construction Cost	35,550 million Kyat



2019-03 Shwebo – Ye-U Road

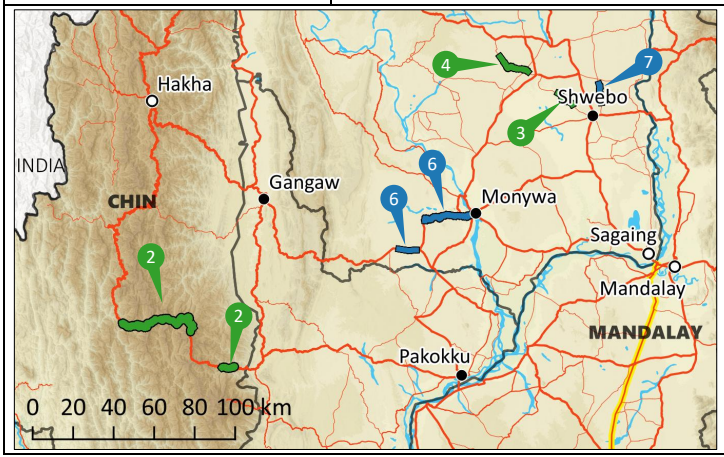
Reference No.	2019-03
Project Title	Shwebo – Ye-U Road
Location	Sagaing
Project Road Length	9.7 km
Road Classification	Primary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Portland Cement Concrete Pavement (W=5.5m)
Natural Disaster Risk	None
Estimated Construction Cost	4,850 million Kyat

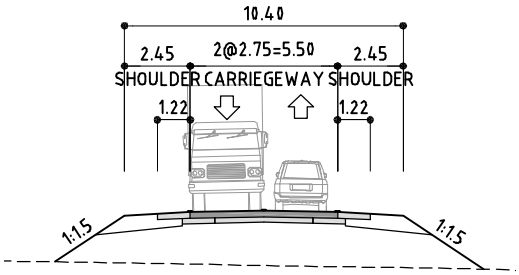




MP-06 Monywa - Pale - Gangaw – Kalaymyo Road

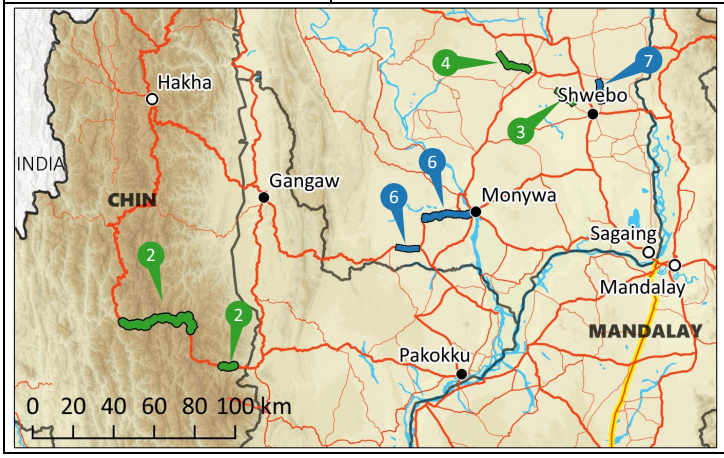
Reference No.	MP-06
Project Title	Monywa - Pale - Gangaw – Kalaymyo Road
Location	Sagaing
Project Road Length	25.8 km + 8.8 km
Road Classification	Primary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Portland Cement Concrete Pavement (W=5.5m)
Natural Disaster Risk	None
Estimated Construction Cost	12,900 million Kyat + 4,400 million Kyat

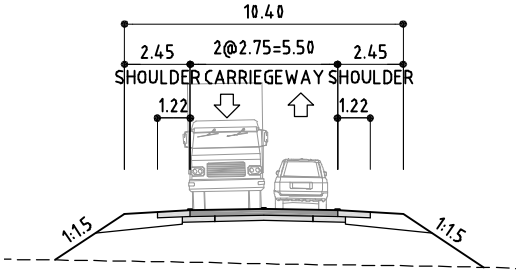




MP-07 Shwebo – Myitkyina Road

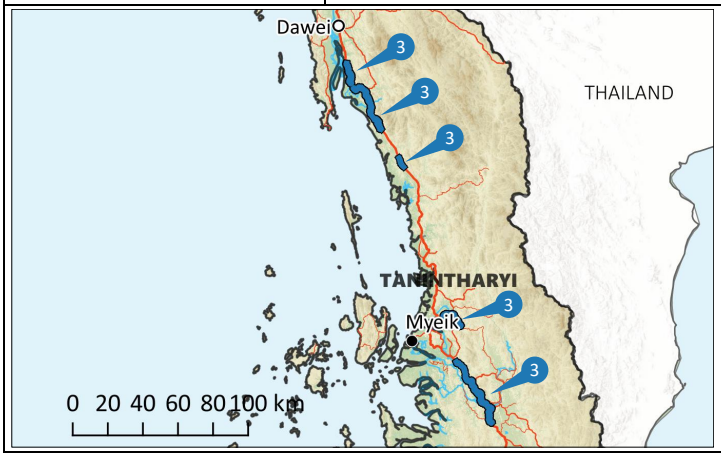
Reference No.	MP-07
Project Title	Shwebo – Myitkyina Road
Location	Sagaing
Project Road Length	10.1 km
Road Classification	Primary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Portland Cement Concrete Pavement (W=5.5m)
Natural Disaster Risk	None
Estimated Construction Cost	5,050 million Kyat

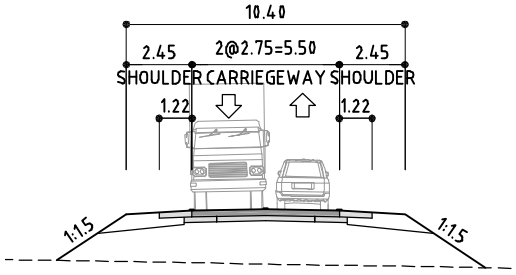




MP-03 Thanbyuzayat – Dawei – Myeik – Kawthonng Road

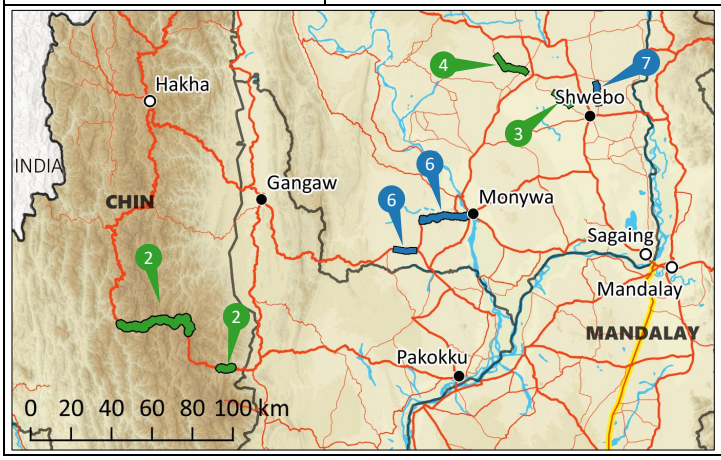
Reference No.	MP-03
Project Title	Thanbyuzayat – Dawei – Myeik – Kawthonng Road
Location	Tanintharyi
Project Road Length	13.5 km + 37.0 km + 6.2 km + 34.5 km + 49.9 km
Road Classification	Primary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Portland Cement Concrete Pavement (W=5.5m)
Natural Disaster Risk	None
Estimated Construction Cost	6,750 million Kyat + 18,500 million Kyat + 3,100 million Kyat + 17,250 million Kyat + 24,950 million Kyat

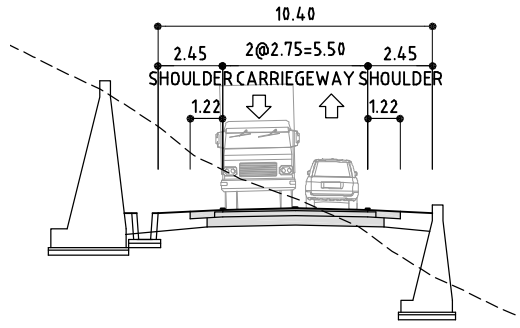




2019-02 Mindat – Matupi Road

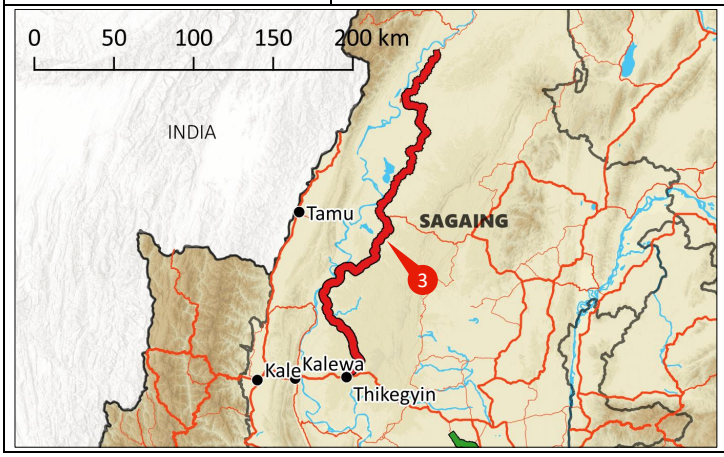
Reference No.	2019-02
Project Title	Mindat – Matupi Road
Location	Chin
Project Road Length	8.5 km + 46.7 km + 39.4 km
Road Classification	Secondary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Penetration Macadam Pavement (W=5.5m)
Natural Disaster Risk	Landslide
Estimated Construction Cost	4,590 million Kyat + 25,218 million Kyat + 21,276 million Kyat

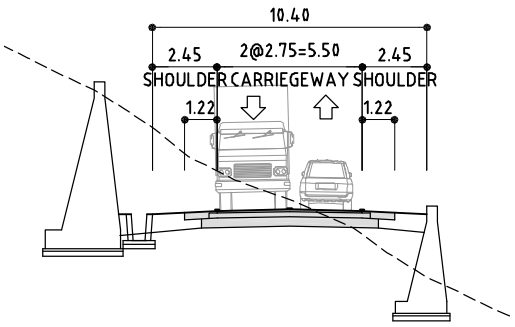




2020-03 Thickegyin – Paungbyin – Homalin – Hkamti Road

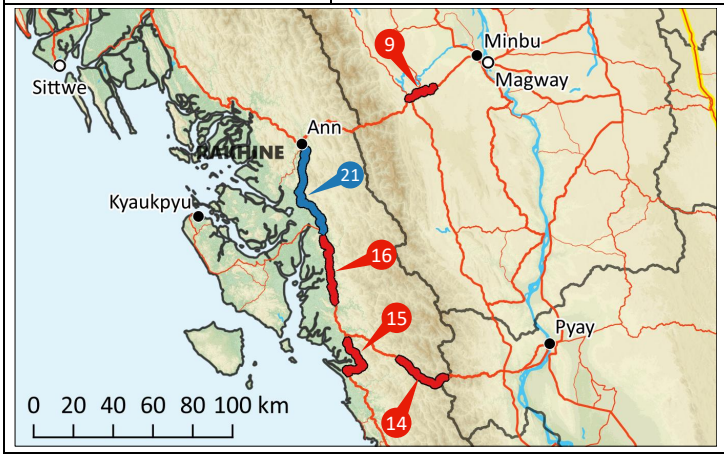
Reference No.	2020-03
Project Title	Thickegyin – Paungbyin – Homalin – Hkamti Road
Location	Sagaing
Project Road Length	49.5 km x 6
Road Classification	Secondary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Penetration Macadam Pavement (W=5.5m)
Natural Disaster Risk	Landslide
Estimated Construction Cost	26,730 million Kyat x 6

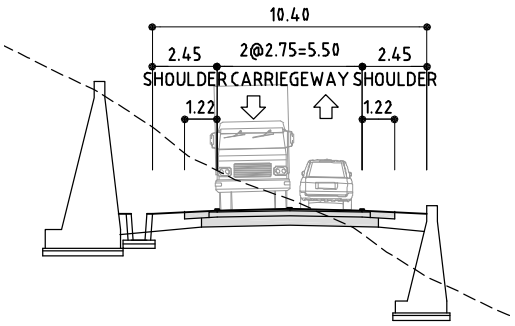




2020-14 Pyi – Taungup Road

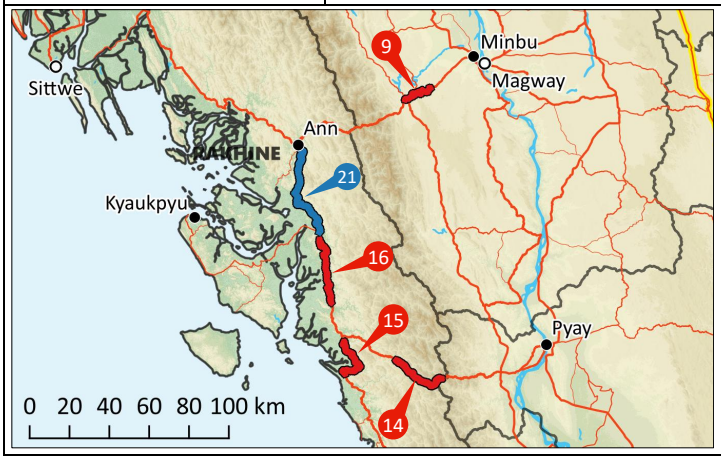
Reference No.	2020-14
Project Title	Pyi – Taungup Road
Location	Rakhine
Project Road Length	40.0 km
Road Classification	Secondary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Penetration Macadam Pavement (W=5.5m)
Natural Disaster Risk	Landslide
Estimated Construction Cost	21,600 million Kyat

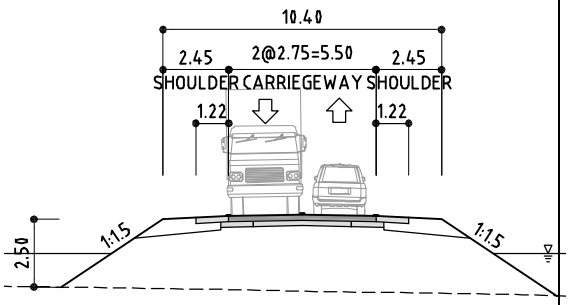




2020-15 Taungup – Thandwe Road

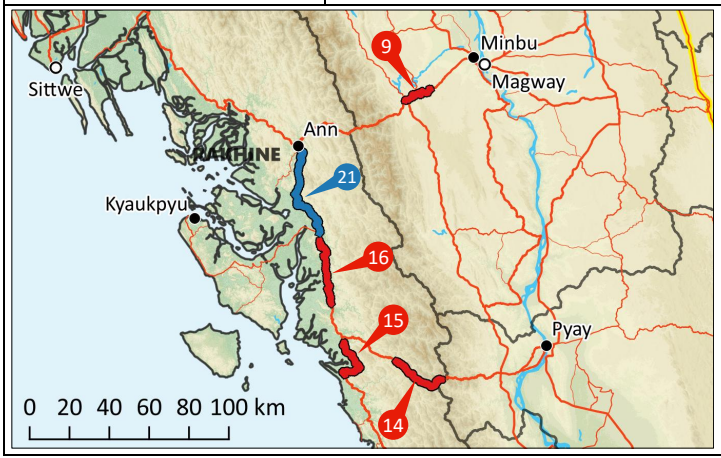
Reference No.	2020-15
Project Title	Taungup – Thandwe Road
Location	Rakhine
Project Road Length	33.4 km
Road Classification	Secondary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Penetration Macadam Pavement (W=5.5m)
Natural Disaster Risk	Flood
Estimated Construction Cost	30,060 million Kyat

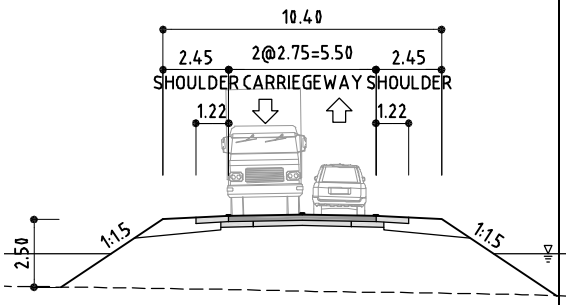




2020-16 Taungup – Maei – Kyaukpyu Road

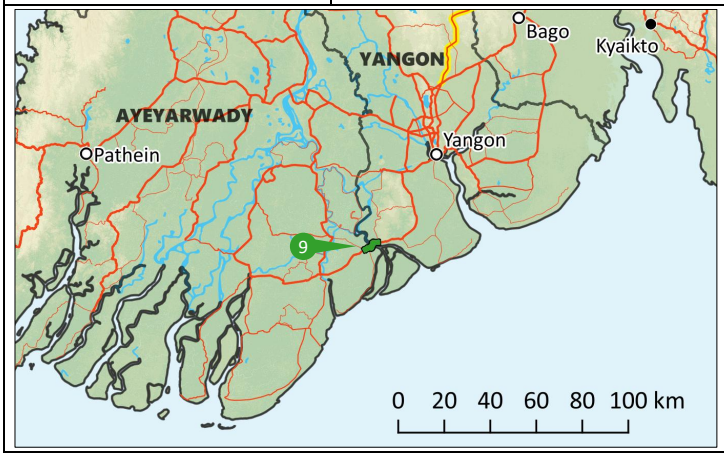
Reference No.	2020-16
Project Title	Taungup – Maei – Kyaukpyu Road
Location	Rakhine
Project Road Length	43.8 km
Road Classification	Secondary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Penetration Macadam Pavement (W=5.5m)
Natural Disaster Risk	Flood
Estimated Construction Cost	39,420 million Kyat

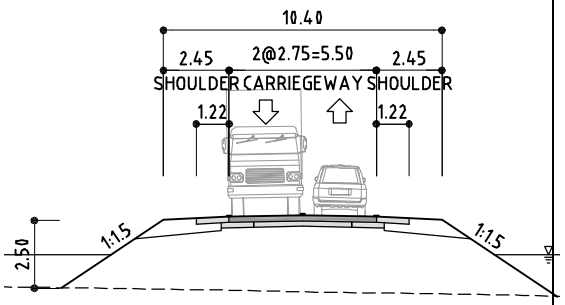




2019-09 Kungyangon – Tawkayan – WestBoatDin Road

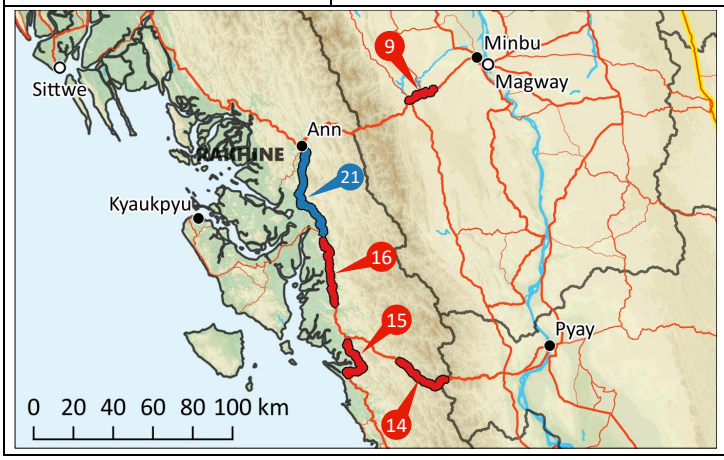
Reference No.	2019-09
Project Title	Kungyangon – Tawkayan – WestBoatDin Road
Location	Yangon
Project Road Length	7.0 km
Road Classification	Secondary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Penetration Macadam Pavement (W=5.5m)
Natural Disaster Risk	Flood
Estimated Construction Cost	6,300 million Kyat

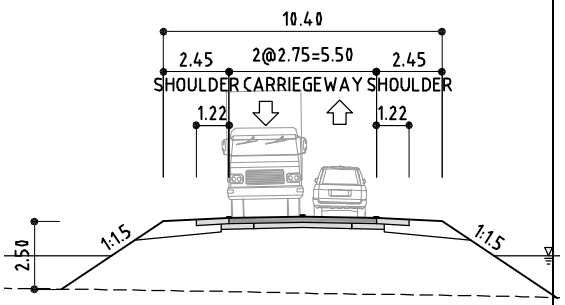




MP-21 Ann – Kyaukpyu Road (Ann-Maei)

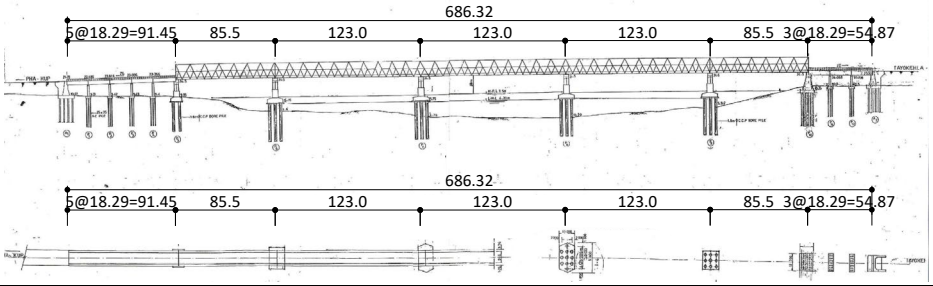
Reference No.	MP-21
Project Title	Ann – Kyaukpyu Road (Ann-Maei)
Location	Rakhine
Project Road Length	34.4 km + 31.0 km
Road Classification	Secondary Arterial Road
Number of Lane	2 lanes (1 lane x 2)
Pavement Type	Penetration Macadam Pavement (W=5.5m)
Natural Disaster Risk	Flood
Estimated Construction Cost	30,960 million Kyat + 27,900 million Kyat

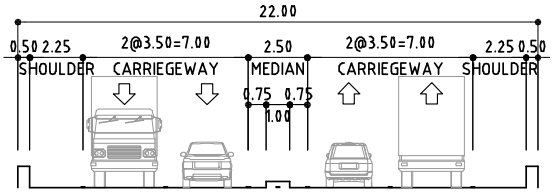




(2) Bridge Improvement Project

Thanlwin Bridge (Hpa-an)

Reference No.	2020-19
Project Title	Thanlwin Bridge (Hpa-an)
Location	Hpa-an, Kayin
Existing Bridge Length	686.32 m 
Road Classification	Primary Arterial Road
Number of Lane	4 lanes (2 lane x 2)
Pavement Type	Asphalt Concrete Pavement (W=10mx2)
Natural Disaster Risk	Flood
Estimated Construction Cost	250,000 million Kyat



8. Project Implementation Plan

8.1 Road Network Development

Improvement of the selected priority road sections can be implemented by local contractors through JICA's sector loan scheme similar to the Regional Development Project for Poverty Reduction Project Phase I and Phase II. However, this Survey could not undertake site survey for confirmation of the necessity of the improvement due to the restriction of international and domestic travels in Myanmar caused by the COVID-19 pandemic. Therefore, supplemental survey should be conducted as listed in **Table 8.1** for finalization of the project scope.

Table 8.1 Required Data in Next Stage

Data	Usage of Data	Collected in this Survey	Next Stage
Road Condition	• Justification of the road sections and bridges to be improved.	• Road inventory data was provided by DOH. • Site conditions could not be undertaken due to COVID-19 pandemic.	• Site survey should be conducted. • Pavement condition survey should be conducted using vehicle with automated sensing equipment for quantitative evaluation of pavement condition.
Traffic Condition	• Justification of pavement type.	• No data could be collected.	• Traffic count survey should be conducted to justify the necessity of asphalt/concrete pavement for the selected road sections.
Bridge Condition	• Justification of necessity of improvement and required length of bridge.	• Bridge inventory data was provided by DOH. • Site conditions could not be undertaken due to COVID-19 pandemic.	• Site survey should be conducted.
Slope Condition	• Justification of necessity of slope protection and required type of protection.	• No data could be collected.	• Site survey should be conducted.
Safety and Security Condition	• Justification of implementability of project.	• Security level guided by Ministry of Foreign Affairs of Japan and EAO active area were collected.	• Further clarification should be made to the local government.
Road Development Policy	• Justification of necessity of project.	• Functional road classification was proposed as a guidance of prioritization of road network.	• Further discussions should be made with MOC.

Source: JICA Study Team

The detailed designs for the Regional Development Project for Poverty Reduction Project Phase I and Phase II were carried out by DOH and DOB and were reviewed by consultant. However, no proper survey and soil tests prior to the preparation of design was carried out in Phase I. There was miscommunication between design team and cost estimate section of DOH and DOB. Therefore, it would be recommended that DOH and DOB should hire the design consultant for undertaking necessary topographic survey, geotechnical investigation and detailed design of civil works.

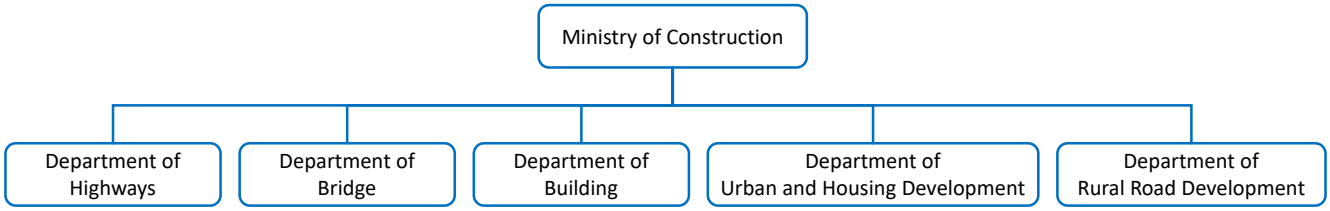
On the other hand, involvement of international contractors would be recommended for construction of Thanlwin Bridge (Hpa-an) and large-scale slope protection works and separate ODA loan should be financed.

In addition to the large-scale slope protection work project, institutional development for slope protection should be carried out in order for DOH to systematically understand the proper procedure of slope stability analysis and countermeasure selection.

8.2 Institutional Development

(1) Current Organizational Structure

The organizational structure of MOC is defined as shown in **Table 8.2**. Department of Highways (DOH), Department of Bridge (DOB) and Department of Rural Road Development (DRRD) take charge of planning, construction, operation and maintenance of roads and bridges as defined in **Table 8.2**.



Source: MOC

Figure 8.1 Organizational Structure of MOC

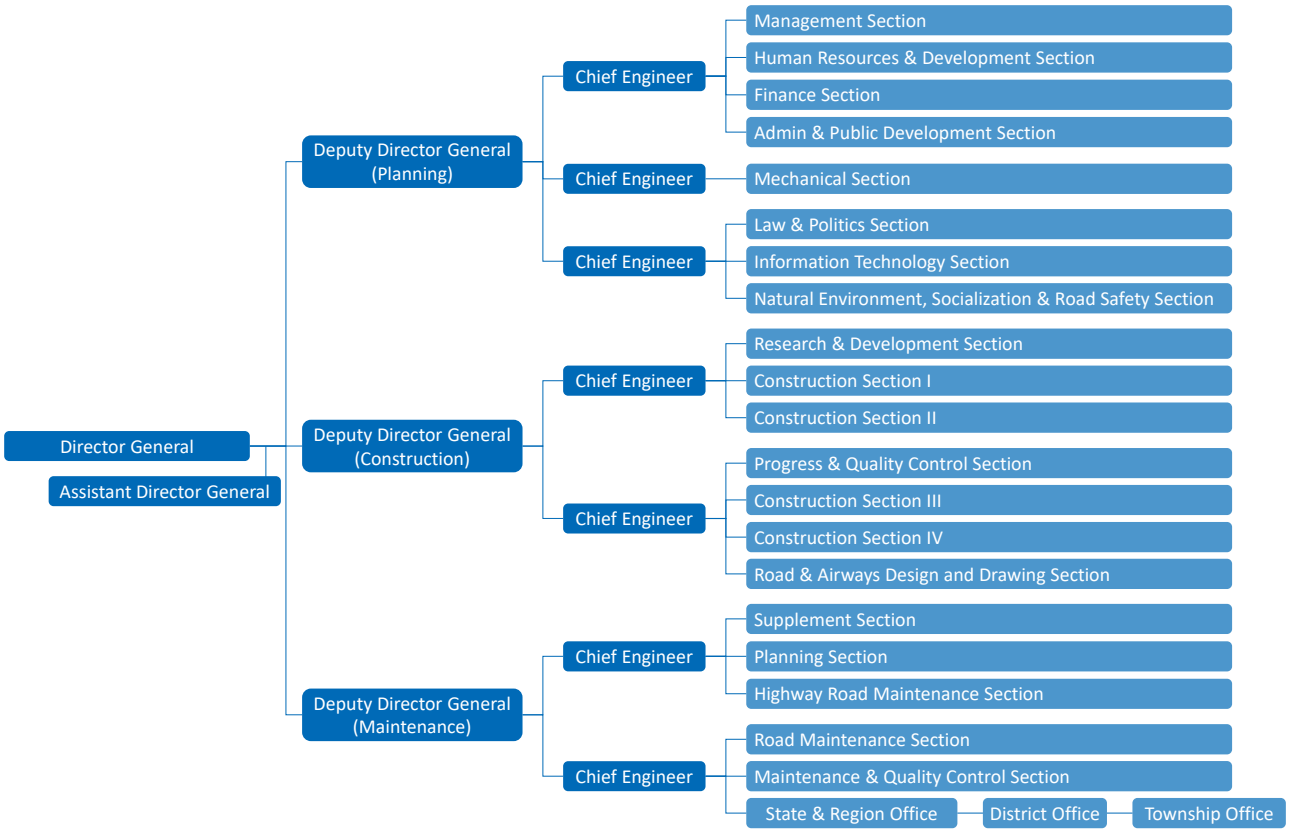


Figure 8.2 Organizational Structure of DOH

Table 8.2 Institutional Demarcation

Component		Responsible Agency
Roads	Expressways and Highways	DOH
	City to City Roads	DOH
	Any other branches connected to DOH roads	DRRD
	Some Township Roads	Township Development Affair Committee
	Villages Roads located at border area	Ministry of Border Affairs
Bridges	Design of all bridges	DOB
	Construction & Maintenance of highway bridges (over 15 m)	DOB
	Construction & Maintenance of highway bridges (less 15 m)	DOH
	Inspection of highway bridges (over 54 m)	DOB
	Inspection of highway bridges (less 54 m)	DOH
	Construction, Maintenance & Inspection of DRRD Roads	DRRD

Source: MOC

(2) Necessity of Establishing Special Unit for Disaster Prevention/Mitigation

DOH should have responsibility for road management against natural disasters but currently there is no special unit handling such matters under DOH. As the Road Bureau of Ministry of Land, Infrastructure, Transport and Tourism (Japan) has the Environment, Safety and Disaster Prevention Division, DOH should establish such unit to improve its natural disaster preparedness.

(3) Necessity of Improvement of Institutional Capability

The necessary action to be taken by DOH to improve natural disaster preparedness would be the following:

- Identification of landslide-prone areas along arterial roads;
- Improvement of technical capacities to plan, design, and construct countermeasures against landslide, including landslide survey and monitoring;
- Improvement of institutional capacity on restoration of arterial roads from damage by landslides.

In order to achieve the above, an institutional development project should be implemented under the support from donor agencies such as JICA. Table 8.3 summarizes the outline of the possible activities under the institutional development project.

Table 8.3 Outline of Possible Institutional Development Project

Narrative Summary	Objectively Verifiable Indicators	
Overall Goal		
Resilience of nationwide road network against landslides is improved.		
Project Purpose		
MOC's technical capacity on landslide countermeasure is improved.		
Outputs		
1. Landslide-prone areas along the designated arterial roads in pilot states/regions are identified.	1-1 Guideline for landslide risk assessment is prepared. 1-2 Inventories of landslide risk along pilot roads are prepared.	
2. Technical capacities to survey, design and construct countermeasures against landslide and to monitor landslide-susceptible slopes are improved through pilot project(s).	2-1 Guideline for survey, design and construction of countermeasures against landslide and monitoring of landslide-susceptible slopes is prepared. 2-2 The number of landslide-prone slopes is reduced when compared between baseline data and endline data.	
3. Institutional capacity on restoration of arterial roads from damage by landslides is improved.	3-1 Guideline for restoration of arterial roads from damage by landslides is prepared. 3-2 Institutional framework for establishing disaster response team(s) is established under DOH/MOC. 3-3 Standard Specifications for restoration works is prepared.	
Activities	**Inputs**	
1.1 Collect and analyze existing information on landslides along arterial roads and identify issues for prevention or mitigation of landslide disasters. 1.2 Conduct field surveys to the pilot states/regions. 1.3 Prepare a guideline for landslide risk assessment. 1.4 Prepare inventories of landslide risk along pilot roads. 2.1 Prepare a guideline for plan, design, and construction of countermeasures against landslide, including landslide survey and monitoring. 2.2 Conduct training courses to put the guideline in practice. 2.3 Support MOC to implement pilot project(s) for countermeasures against landslide. 2.4 Monitor and evaluate the pilot project(s). 3.1 Support towards proper set-up of institutional framework for establishing disaster response team(s). 3.2 Prepare a guideline for restoration of arterial roads from damage by landslides. 3.3 Conduct training courses to put the guideline in practice. 3.4 Support the disaster response team(s) after occurrence of landslides. 3.5 Prepare Standard Specifications for restoration works.	<u>Myanmar Side</u>	<u>Japanese Side</u> 1. Dispatch of Experts 1) Team Leader/ Landslide Countermeasure Expert* 2) Landslide Survey Expert 3) Landslide Countermeasure Design Expert* 4) Slope Monitoring Expert 5) Road Planning Expert 6) Road O&M Expert 7) Construction Supervision Expert 8) Equipment Operation Expert 9) Project Coordinator 2. Oversea Trainings 3. Cost for pilot project(s) including procurement of equipment 4. Others (office equipment for project office)

Source: JICA Study Team

(4) Details of Institutional Development Project

Identification of Landslide Prone Areas along Arterial Road (Activities 1.1~1.4)

As explained in Chapter 5, identification of landslide prone areas requires several steps:

1) Collection of existing information including topographic, geological, and seismic zone maps, rainfall data, and disaster records,

2) Map reading with elevation contour map,

3) Screening of roadside slopes with the abovementioned information to select dangerous slopes to be inspected,

4) Field survey to prepare General Information Sheets and Slope Stability Assessment Charts, which are basis for slope inventory,

5) Prioritization of dangerous slopes into three categories; slopes which require countermeasures, slopes to be kept under observation, and slopes to be listed in slope inventory.

Through the above mentioned steps, candidate site(s) for pilot project(s) for Activity 2.3 may be selected.

The steps of 4) and 5), preparation and operation of slope inventory, are originally for operation and maintenance (O&M) period; slope inventory facilitates regular and emergency inspections, through which road administrators can monitor conditions of dangerous roadside slopes.

The technologies relating to slope inventory require technical transfer; a technical cooperation project with several experts and a project period of 2 ~ 3 year may realize such technical transfer. In the planned institutional development project, however, prioritized technical transfer should be made for design and construction of landslide countermeasures as well as restoration of damaged road. Thus minimum and essential technical transfer should be made for preparation of slope inventory.

Selection of the site(s) for pilot project(s) affects efficiency as well as cost of the project. Thus careful selection should be made by both Japan and Myanmar sides.

A large site may require huge project cost, which are unable to be handled in a technical cooperation project and should be treated in a grant or loan project. Technical cooperation project should select relatively small scale site(s), which suits effective demonstration of new technology.

Improvement of Technical Capacities to Plan, Design, and Construct Countermeasures against Landslide, including Landslide Survey and Monitoring (Activities 2.1~2.4)

a) Survey and Monitoring of Landslides

This output relates to Chapter 5.4 (2) and Chapter 5.5.1 and 5.5.2.

To design and construct countermeasures against landslide, landslide survey and monitoring are crucially important. Thus the project should allocate sufficient time for technical transfer for survey and monitoring of landslide.

Usually, landslide monitoring should cover a monsoon season as well as some periods of preceding and following dry seasons to understand behavior of a landslide during rainy seasons. Landslide monitoring including groundwater level variation and surface/subsurface displacement is essential for design of countermeasures against slides and gravity deformation.

On the other hand, topographic survey and drilling investigation should be done in dry seasons so that safety and efficiency of the surveys are secured. At the same time, boreholes of drilling survey are utilized for landslide monitoring; monitoring equipment such as groundwater monitoring wells with automated groundwater level meters as well as borehole extensometers are installed into the boreholes after drilling investigation.

Such survey and monitoring of landslide should be exercised at the selected pilot project site(s) so that technical transfer can be made through actual practice.

b) Countermeasures for Pilot Project(s)

Chapter 5.5.1 and 5.5.2 explain typical types of countermeasures against collapse, slides, and gravity deformation as well as slope works and protection works. Among the works explained in the said chapters, concrete crib works and horizontal drainage boring are suitable for pilot project(s).

Both works are versatile and expected to be used widely in Myanmar after introduced by the project, due to its simple structure, easiness of procurement of materials as well as construction, and wider application to landslide mitigation.

Improvement of Institutional Capacity on Restoration of Arterial Roads from Damage by Landslides and Issuing Warnings against Landslides (Activities 3.1~3.5)

a) Restoration of Arterial Road

This output relates to Chapter 5.5.5.

Damage by landslides can be roughly divided into two types; accumulation of debris on road surface and damage of road bed by landslide movement. Accumulation of debris can be handled by local engineers in Myanmar but damage of road bed is difficult to restore.

Technical transfer of road bed restoration should be made for survey, design, and construction, including preparation of guideline for dissemination and technical specification for procurement of the works with new technologies.

A machinery to construct pile wall was introduced in a JICA funded project, the Project for Improvement of Road Construction and Maintenance Equipment in Kachin State and Chin State. This machinery is utilized for restoration of road bed in mountainous region, in combination with new technologies such as air-mixed cement or mortal.

Exclusion of Debris Flow and Rock Fall

As explained in Chapter 5.3, landslide has a wide variety of classification.

On the other hand, similar types of countermeasures are applied for collapse, slides, and gravity deformation, whereas rock fall or debris flow requires specific types of countermeasures.

Similarly, similar types of landslide investigation and monitoring are applied for collapse, slides, and gravity deformation, whereas rock fall or debris flow requires specific types of investigation.

In the aim of effective realization of the project with limited cost, resources should be concentrated to the survey and countermeasures against collapse, landslide, and gravity deformation.

In terms of frequency of occurrence, collapse, slides, and gravity deformation occupies large portion of the occurrence of landslides.

Thus debris flow and rock fall should be excluded from the scope of the project.