

Current Situation and Issues of Myanmar's Bridge Work

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Some new findings from the study [Research Study on Review and Application of the Bridge Engineering Training Center Project in Myanmar] by JICA,2012

1. Introduction

In Myanmar, the Japan International Cooperation Agency (JICA) conducted the Bridge Engineering Training Center Project (BETC) from 1979 to 1985 for engineers of the former Construction Corporation (currently Public Works [PW]) which is a subsidiary organization of the Ministry of Construction (MOC).

Under the project, in-center training and on-the-job training were conducted under the guidance of Japanese experts dispatched to Myanmar. Through the former, around 60 engineers mastered the design methods of bridge substructures, reinforced concrete bridges, and prestressed concrete bridges, and through the latter, a prestressed concrete bridge called the Thuwunna Bridge was constructed using a cantilever beam overhanging construction method with an effective span of 100m.

Through the on-the-job training, engineering technologies for bridge substructures such as cast-in-place pile and temporary work using vibrohammer were introduced, and the application of these technologies even after the end of the project has improved bridge construction capabilities in Myanmar dramatically.

More specifically, in the suburbs of Yangon a cable-stayed bridge with an effective span of 300m has been constructed, while seven long-span bridges have already been constructed over the Irrawaddy River (until then there was a single bridge initially built in 1900 during the British colonial era), and a further five bridges are under construction over the Irrawaddy River including a total length of over 3,000m.

However, considering the current situation in which Myanmar is pursuing the construction of new bridges, with disruption to technical support from several nations including Japan since 1990, the very strict construction period required (a 3,000m length bridge in as little as 3-4 years), and limited construction materials and equipment, it was thought necessary to verify the current state of Myanmar's bridge construction technology from the BETC onwards.

This report outlines the current situation of, and issues within Myanmar's bridge construction based on field survey on bridges in Myanmar that the Ministry of Land, Infrastructure and Transport commissioned Japan Infrastructure Partners (JIP) to conduct in 2010 and 2011.

At the end of this report, some new findings are added from the study [Research Study on Review and Application of the Bridge Engineering Training Center Project in Myanmar] by JICA,2012 (JIP could have chance to join the study in Myanmar as the observer) .

Lastly, we JIP would like to express our thanks to Oriental Consultants Co.,LTD. for their cooperation to translate this report..

2. Overview of the Bridges in Myanmar

Fig -2.1 shows a map of Myanmar.



Figure—2.1 National Map of Myanmar

The number of bridges in Myanmar as of 2009 is shown in the data in Table 2.1. This data covers 34,178 km of roads governed by the MOC within the total 130,050 km of roads in Myanmar overall.

According to the data, there are a total of 4,263 bridges, of which 276 are 180 feet (54m) or more in length, and 3,987 are shorter.

Table—2.1 Number of Bridges in Myanmar under MOC Control

Bridge length (feet(m))	Number of bridges
Less than 50(15)	2,886
50(15)~100(30)	777
100(30)~180(54)	344
Over 180(54)	276
Total	4,263

Furthermore, for bridges of spanning 180 feet or longer (54m), the PW has data from 2011 which shows the number of bridges in each state and each region constructed before and after 1988 (Table 2.2).

This also includes bridges not under MOC control, and comparing the figures of Tables 2.1 and 2.2 in relation to bridges spanning 180 feet (54m) or longer, the MOC controls 276 bridges, and there are 465 bridges including those not under its control, and though there was some discrepancy at the time of the study, it can be understood that this difference of 189 bridges is mainly the number not under MOC control.

According to Table 2.2, of the bridges spanning 180 feet (54m) or longer, there are a total of 465 bridges, with 198 completed before 1988 and 267 completed thereafter. More specifically, this was limited to bridges spanning 180 feet (54m) or longer, and the number of bridges built over the 20 years or so from 1988 to 2007 (267 bridges) exceeds that built before 1988, and it is surmised that bridge construction moved at a faster pace over this 20 year period than previously.

Table-2.2 No. of Bridges in Myanmar Spanning 180 ft (54m) or longer

State or Region	Constructed before 1988	Constructed after 1988
Kachin State	27	21
Kayah State	6	2
Chin State	2	3
Sagaing Region	17	21

Magwe Region	20	23
Mandalay Region	18	16
Shan State	24	19
Kayin State	8	8
Tanintharyi Region	8	7
Bago Region	36	20
Mon State	3	4
Rakhine State	11	37
Yangon Region	7	30
Ayeyawady Region	11	56
Total	198	267
Grand total	465	

Tables 2.1 and 2.2 do not specify bridge type, but of the bridges focused on in the inspection of major bridges conducted by the PW in 2009, the number of bridges by type in Yangon Region and Ayeyawady Region are shown in Table 2.3.

According to Table 2.3, a total of 77 bridges were inspected in both regions, and considering that the inspection focused on main bridges, it is surmised that these were selected from 90 bridges in both regions spanning 180 feet (54m) or more as indicated in Table 2.2.

The breakdown of the total of 77 bridges inspected in both regions is as follows: 43 concrete bridges (55.8%), 13 steel truss bridges (16.9%), 9 cable-stayed/suspension bridges (11.7%), and 12 Bailey bridges (15.6%).

More specifically, while the majority is reinforced concrete and prestressed concrete bridges, nearly half are steel truss, cable-stayed/suspension or Bailey bridges.

Table—2.3 Target bridge in Yangon Region and Ayeyawady Region at the time of bridge inspection in 2009

	RC bridge, PC bridge	Steel truss bridge	cable-stayed bridge, Suspension bridge	Bailey bridge	Total
Yangon Region	19	3	3	5	30
Ayeyawady Region	24	10	6	7	47
Total	43	13	9	12	77
	55.8%	16.9%	11.7%	15.6%	100%

Though there is no data on the types of bridges spanning 180 feet (54m) and less, considering the construction situation in Myanmar to date, concrete is frequently used for shorter bridges while steel tends to be used for longer bridges. Therefore, the ratio of concrete bridges is higher among bridges spanning 180 feet (54m) or less than among longer bridges, and so the proportion of steel bridges is thought to be low.

Note that even though it was stated in the introduction (1.) that almost all the superstructures of Myanmar's long-span bridges are purchased from a Chinese bridge manufacturer, the state enterprise of the Myanmar Economic Corporation placed orders with Japanese corporations, and in 2000 a steel plate rolling factory and an H-beam factory were completed, followed by a steel bridge factory with the latest equipment in 2001. Furthermore, steel bridges are being manufactured under the guidance of Japanese corporations, and the Chindwin Bridge was constructed by PW as on-the-job training. This bridge is a long-span bridge with a total length of 837m and is comprised of two sets of consecutive trusses of four effective spans of 104m and has a total steel weight is over 4,000 tons.

Subsequently, two bridges of the same type were constructed (though one set has a total length of 400m), and of the five bridges currently under construction over the Irrawaddy River, two are being constructed in the same fashion under the guidance of a Japanese corporation.

Similarly, though almost all small-to-mid length bridges were conventionally Bailey bridges or concrete bridges, since the construction of the factories mentioned above, many plate girder bridges, including several bridges along the Yangon-Mandalay Expressway have been constructed.

As it happens, though it tends to be assumed that long-span bridges in developing nations are constructed with overseas assistance, many bridges in Myanmar are being constructed with state funds on the nation's own responsibility.

More specifically, though there is a dependence on overseas corporations for the design and manufacture of the steel superstructures of long-span bridges (which are partially manufactured domestically under the guidance of Japanese corporations as described above), the basic plan of the bridge and substructure design and construction is implemented by PW itself, and the installation of the superstructure is also implemented by PW under the guidance of several engineers from the bridge manufacturers.

3. Outline of the Bridge Full Inspection Conducted in Myanmar in 2009

In late August 2010, Professor Daw Khin Than Yu of the Yangon Technological University visited Japan, and according to the hearing and materials from the Professor, the mass bridge inspection conducted in Myanmar in 2009 can be summarized as follows.

According to the Professor, in 2009 the government instructed relevant agencies to, "investigate the soundness of Myanmar's bridges in light of recent bridge collapse overseas," and PW was central to a study of bridges in coastal states (Rakhaing, State, Ayeyarwady Region, Mon State, Taninthary Region, and also the Yangon Region).

Out of five study groups, the Professor leads the Yangon and Irrawaddy area study group. A report (in Burmese) from the Professor's study group and a DVD containing many images including the results of other groups' studies was obtained from the Professor.

Photo - 3.1 is of the Yangon and Irrawaddy area inspection team, with Professor Daw Khin Than Yu in the center.

Photo - 3.2 shows a concrete bridge in service whose girders are nearly falling down from substructure. The superstructure appears to be PC girders, and it appears for some reason that manufactured precast girders were simply installed on the pier constructed in incorrect position (it is unlikely that it was left long time in this state with no measures taken, so this bridge was investigated in the 2011 study. The results will be discussed later).



Photo-3.1 Yangon and Irrawaddy region inspection team



Photo-3.2 Concrete girder nearly from substructure

Photos - 3.3 & 3.4 show a case where the rear face of an abutment has been scoured. Photo - 3.3 shows a situation where the flow of traffic was secured using a temporary bridge. Photo - 3.4 shows the later situation where traffic was halted after flooding washed away a temporary bridge support. Judged from the date of the photos, it is thought that this trouble

occurred after the inspection team's observation. Subsequently the bridge was apparently extended in a rush job using a 2-span concrete bridge.



Photo-3.3 Passage of traffic was secured by using a temporary bridge when the rear face of an abutment was scoured during flooding



Photo-3.4 Subsequent flooding washed away the temporary bridge pier and traffic was halted

Photos - 3.5 & 3.6 show deformed locker shoes on the Maubin Bridge which spans a branch river of the Irrawaddy on the Yangon-Pathein road.



Photo-3.5 Deformed shoe of the Maubin Bridge (1)



Photo-3.6 Deformed shoe of the Maubin Bridge (2)

Photos - 3.7-10 show the situation of a Bailey bridge and its pipe pier in the Irrawaddy delta area. Apparently, the pier of a similar bridge collapsed after observation by the inspection team. This region is prone to seawater intrusion, and it seems that the corrosion of a steel pipe caused the pier to collapse. Apparently, just after it collapsed, this bridge was reconstructed as a concrete bridge.



Photo-3.7 Bailey girder bridge



Photo-3.8 Structure of the deck



Photo-3.9 Pipe pier



Photo-3.10 Deterioration of pipe

Photos - 3.11 - 13 and Figure - 3.1 show defective construction work and later repairs to the upper section of cast-in-place concrete pile of the bridge foundations widely used in Myanmar.



Photo-3.11 Section of poor execution at the pile top



Photo-3.12 Section of poor execution at the pile top



Photo-3.13 Repair of pile top

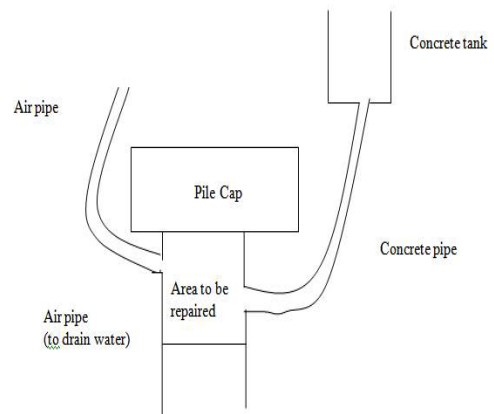


Figure-3.1 Method of repair at a section of poor execution at the

Photos - 3.14 & 3.15 shows a Schmidt Hammer being used in an inspection. Photos - 3.16 & 3.17 show a diver surveying a submerged section of a pile, and the underwater photography.



Photo-3.14 Survey using a Schmidt Hammer



Photo-3.14 Survey using a Schmidt



Photo-3.16 Survey of pile in the water



Photo-3.17 Pile in the water

4. Outline of the Bridges Surveyed

The main bridges that were inspected in 2010 and 2011 have been rearranged in order of the construction date.

Table—4.1 Bridges Inspected

No	Bridge name	Type(Main bridge)	Completion	Span arrangement (Main bridge)
1	Kyaungkong	Truss	1989	$4 \times 36.58 = 182.9\text{m}$
2	Thakhut	Concrete Girder	1991	$9 \times 16.5 = 148.5\text{m}$
3	Thanlyin	Truss with rail	1993	$80 \times 3 + (104 + 112 \times 2) + (112 \times 3) + (112 \times 3) + (112 \times 2 + 104) + 80 \times 3 = 1,808\text{m}$
4	Bayinaung	Truss	1994	$65.6 + (3 \times 123) + 65.6 = 501.1\text{m}$
5	Myaungmya	Suspension	1996	$39.6 + 182.9 + 39.6 = 262.1\text{m}$
6	Maubin	Truss	1998	$(4 \times 120) = 480\text{m}$
7	Bomyatun	Truss	1999	$96 + (3 \times 120) + (4 \times 120) + (4 \times 120) + (3 \times 120) + 96 = 1872\text{m}$
8	Yar Yamaung	Suspension	1999	304.8m
9	Da let- Chaung	Bailey	1999	301.8m
10	Aungzaya	Cable Stayed	2000	$140.8 + 300 + 140.8 = 581.6\text{m}$
11	Mahar Bandoola	Cable Stayed	2000	$55 + 130 + 55 = 240\text{m}$
12	Shwe Pyithar	Truss	2001	$84 + 120 \times 3 + 84 = 528\text{m}$
13	Min Chaung	Truss	2006	$(64 + 84 + 64) = 212\text{m}$
14	Lonedawpauk	Truss	2004	$35 + 60 + 35 = 130\text{m}$
15	Pathein	Suspension	2004	$86 + 255 + 86 = 427\text{m}$
16	Min Kyaung Chaung	Truss	2006	$(3 \times 35) + 60 + (3 \times 35) = 270\text{m}$
17	Twantay	Suspension	2006	$80.8 + 263.3 + 80.8 = 424.9\text{m}$
18	Dagon	PC Cantilever Girder	2007	$27.4 + (48.8 \times 16) + 27.4 = 835.6\text{m}$
19	Tha Yu-Pa-PA done	Suspension	2010	122m

1) Kyaunkong Bridge

The Kyaunkong Bridge completed in 1989 is one of 11 small-to-mid sized truss bridges along the Yangon-Pathein road. The Yangon-Pathein road was improved in the 1980s with Swiss assistance and technical guidance (Photo 4.1). The superstructure trusses of these bridges were purchased from an Australian manufacturer.



Photo—4.1 Kyaunkong Bridge

The concrete slabs of this truss bridge were designed under Swiss technical guidance. Though the lower section of the slabs uses 3.5 inch thick precast concrete members with tensile longitudinal rebars placed within, there was no particular consideration of integration with the cast-in-place concrete section on top.

While it is thought that this type concrete slabs cannot withstand substantial repetitive loading by heavy vehicles, no particular signs of deterioration have been seen as yet (Photo 4.2).

Concrete slabs of the same design were also used in the truss bridges constructed on Kyaukphyu Island at the beginning of 2000. In this region seawater was used for concrete mixing, so these concrete slabs sustain massive damage (See Photo-4.76)



Photo—4.2 Concrete slab of Kyaunkong Bridge

2) Thakhut Bridge

The Thakhut Bridge is a prestressed concrete girder bridge constructed in 1991 in the delta (soil in this area is very soft when compared to the Irrawaddy delta) of the Yangon opposite shore side of Yangon City, and a girder of this bridge noted in the 2010 report was nearly falling from the bridge substructure (Photos 4.3 -5).



Photo—4.3 Thakhut Bridge



Photo-4.4 Concrete girder nearly falling from substructure



Photo-4.5 Temporal installed support

Figure 4.1 shows the general view and photos before and after widening of the top of the pier (the general view was drawn in the opposite direction to the direction the photos were taken).



Figure-4.1 General view and Photos(before and after)

The abutment of the Yangon side moved forward substantially when the rear embankment of the abutment was filled, and in response, a 2-span concrete girder bridge was extended on the Yangon side.

When an abutment moved during construction and a concrete girder was nearly falling from the central pier, as noted in the 2010 survey report, naturally the pier top would have been widened at that time. Similarly, the pier is rather far from the abutment so it is unlikely that this pier moved when the abutment moved.

So, why did this pier move later? This was considered as follows.

Compared with the Irrawaddy region, this region is a soft delta area, and is an estuarine basin with a large tidal range. For this reason, there is a fairly rapid daily up and down flow in this area, and the river channel moves easily (rivers meander dramatically in delta areas, and many river-bed lakes are also seen).

The river channel around this bridge section has moved in these 20 years after construction, and the riverbed level changed also. In other words, it is believed that the elevated riverbed caused lateral flow of soft ground soil and the pier above was moved.

If the PW staff had showed concern over the movement of this abutment during construction and after and continued to measure the bridges behavior, they might have noticed the bridge substructure on the soft soil would move easily, and they would have likely been able to minimize any similar trouble occurring later. No doubt this is a harsh words for the PW that has been pursuing new bridge construction work.

3) Thanlyin Bridge

The Thanlyin Bridge is a road-rail bridge over the Bago River in south-eastern Yangon, and was completed in 1993 with grant assistance from China (Photos 4.6 & 7). The structure is one of a single railway track with two roads either side, and a pipeline.



Photo-4.6 Thanlyin Bridge



Photo-4.7 Thanlyin Bridge

In contrast to later bridge construction in Myanmar, the bridge was constructed by the assistance of the Chinese government and carried out almost entirely by a Chinese workforce.

The bridge was maintained by the Ministry of Rail Transport, and though nearly 20 years have elapsed since it came into service, the bridge appears to have been relatively well maintained.

4) Bayinaung Bridge

The Bayinaung Bridge was constructed in western Yangon and was the first erected over the Hlaing River. It is a two-lane truss bridge (Photo 4.8, fig. 4.2).



Photo-4.8 Bayinaung Bridge

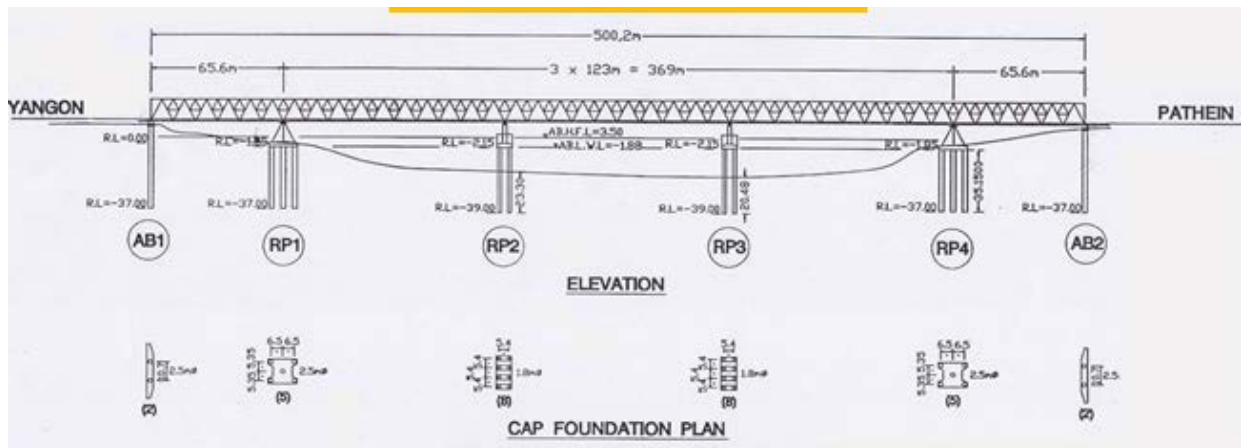
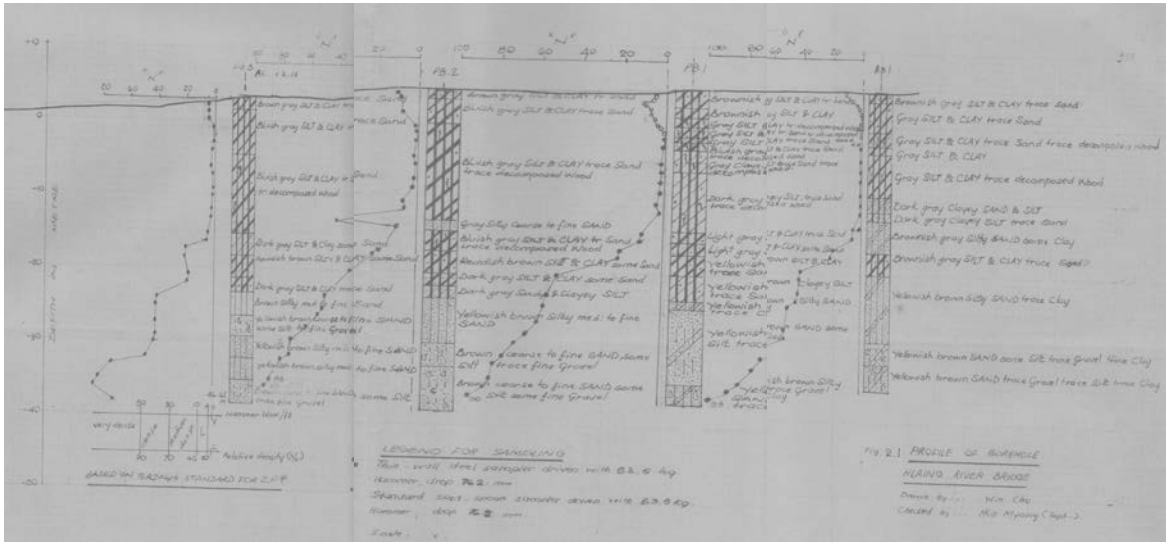


Figure-4.2 General view of Bayinaung Bridge

Soil condition in this area is typically of soft layers (Fig. 4.3), and the Yangon opposite abutment has been pushed forwards due to earth pressure on its rear embankment and gave compressive force on the truss superstructure. In 2003, large-scale repairs work was done by suspending the traffic.



Figure—4.3 Boring log of the Bayinaung Bridge

Photo 4.9 shows a movable shoe on the Yangon side of which bearing plate was elongated. The shoe on the opposite shore side, as shown in Photo 4.10, appears to be functioning comparatively soundly.

As for the expansion joints on both sides, the teeth began to collide so in response the claw was cut during large-scale repairs. However, at present the gap of the expansion joint has disappeared (Photo 4.11), and partial fractures can be seen in some sections (Photo 4.12). So it is thought that the abutment is still moving and countermeasures would be required.



Photo—4.9 Movable shoe (Yangon side)



Photo—4.10 Movable shoe (Yangon opposite shore side)



Photo-4.11 Expansion joint
(Yangon side)



Photo-4.12 Expansion joint
(Yangon opposite shore side)

Photo 4.13 shows a precast concrete slab. This precast slab is reinforced with longitudinal ribs, and there appears to be no problems with the strength of the joints.

Photo 4.14 was taken at the time of the full inspection in 2009 and shows the situation of the underside of the top slab (known as a "pile-cap" within PW) supporting the bridge pier. The rebars are exposed.

The type of pier foundation used in the Nguwun Bridge which was constructed as a follow-up project of the BETC(The pier is supported on the pile-cap supported by the cast-in place concrete piles projected from riverbed) is used in construction over Myanmar's large

rivers including the Bayintnaung Bridge.

It is thought the design and execution requires investigation when it's used in deep river.



Photo-4.13 Precast concrete slab



Coverless of Pile Cap bottom surface
at Bayintnaung Bridge

Photo-4.14 Underside of a pile cap

Rubbish has collected at the panel points of the trusses, and such a state is susceptible to corrosion (Photos 4.15 & 16). Preventing corrosion of truss panel points was suggested as a crucial maintenance item.



Photo-4.15 Panel point of truss



Photo-4.16 Dust at panel point

5) Myaungmya Bridge

The Myaungmya Bridge is a suspension bridge constructed in the center of the Irrawaddy delta in 1996 (Photo 4.17).



Photo-4.17 Myaungmya Bridge



Photo-4.18 Anchorage (south side)

An abutment of this bridge moved forward while erecting the main cable, the embankment on the rear face of the abutment was changed to a concrete bridge in order to eliminate earth pressure from the rear face of the abutment, and piles were cast around the abutment as a countermeasure. Photo 4.18 shows the abutment on the south side. The top of the main tower was moved over 1m, and the inclination of the main tower can be seen in Photo 4.19.

Apparently the bridge manager was also unsure of the strength of this bridge, and has restricted the two-lane flow of traffic to a single lane using a line of rocks on the road surface, as can be seen in Photo 4.20.



Photo-4.19 Inclined tower



Photo-4.20 Rocks put on the road surface

The connection between the main cable and hanger has been corrosion proofed using a material thought to be cement mortar and as shown in Photo 4.22, the main cable has simply been passed straight through the flooring. The road surface is comprised of I-type steel, and as can be seen from Photo 4.23, a simple expansion joint was used between abutments.

There are concerns over the durability of all the above and it was suggested that this bridge needs to be maintained while keeping in mind all these concerns.



Photo-4.21 Corrosion proofing by cement mortar?



Photo-4.22 Cable passes through the road surface



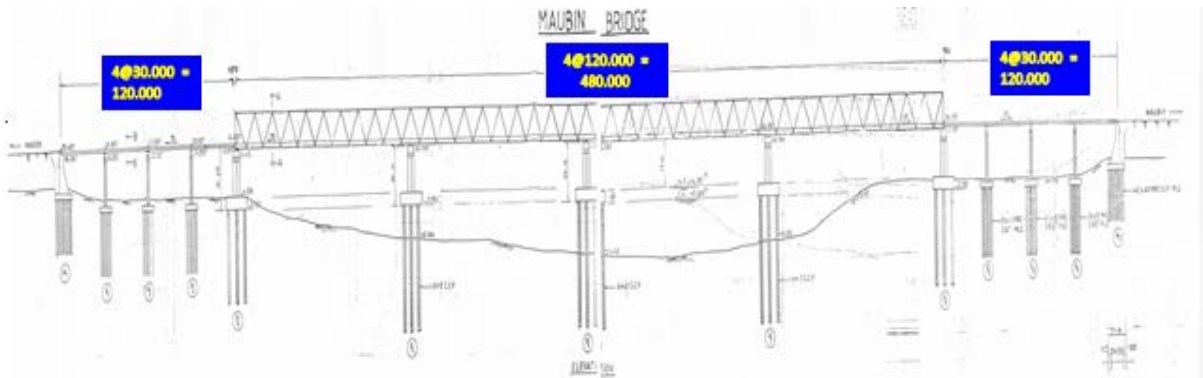
Photo-4.23 Expansion joint

4) Maubin Bridge

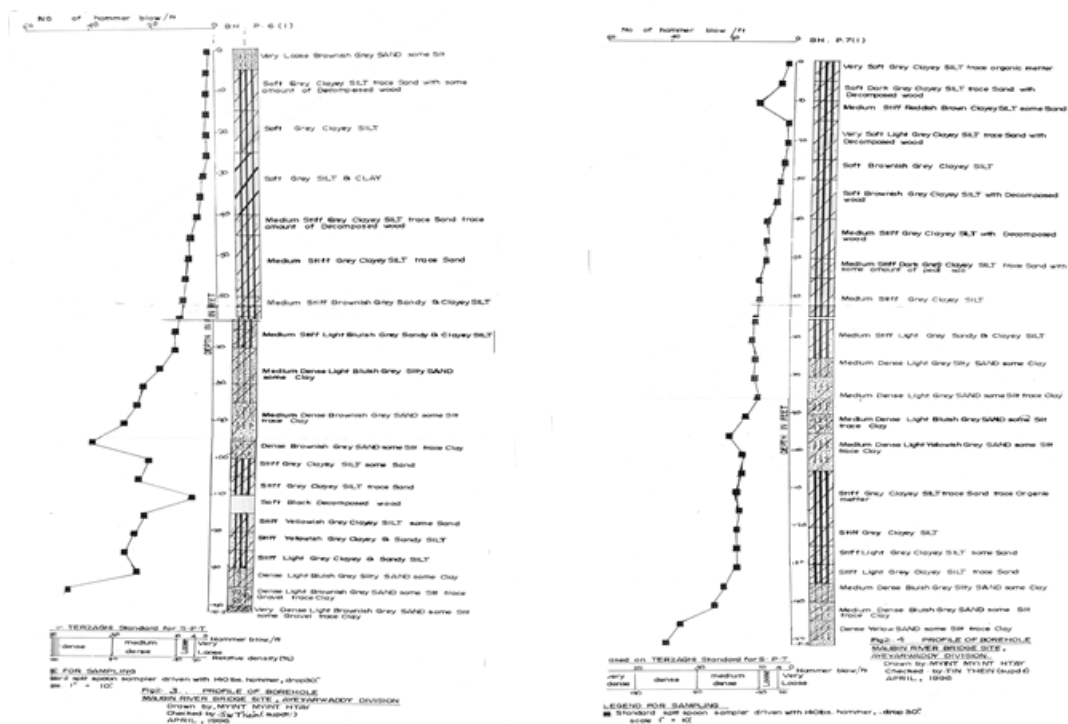
The Maubin Bridge was completed in 1988 in a region of soft soil within the Irrawaddy delta belt, and the bridge's shoes are greatly deformed (Photo 4.24, figs. 4.4 & 5).



Photo—4.24 Maubin Bridge



Figure—4.4 General view of Maubin Bridge



Figure—4.5 Boring log of the Maubin Bridge

In the same way as with the Bayinaung Bridge, the abutment that sits upon soft soil has moved forward due to earth pressure on its rear face, and this is thought to put pressure on the truss superstructure.

Photo 4.25 shows that the rubber shoe of the approach concrete bridge atop of the truss bridge's end pier has been severely shear deformed, and we can see that the pier has been pushed from the concrete bridge side.



Photo—4.25 Rubber shoe subject to major shear deformation

As shown in Photos 4.26 & 27, the main body of the locker shoe is greatly deformed, and

on the Maubin side the stopper of the lower shoe has become detached.



Photo-4.26 Shoe (Yangon side)



Photo-4.27 Shoe (Maubin side)

Likewise, Photos 4.28 & 29 show the expansion joint and parapet atop the abutment of the approach concrete bridge, and it is clear that earth pressure is acting on the rear face of the abutment.



Photo-4.28 Expansion joint (Maubin side)



Photo-4.29 Abutment (Maubin side)

This bridge also uses precast concrete slabs, though there are concerns about its durability since prestress has not been introduced into the cast-in-place concrete joint between the precast slabs (Photo 4.30).



Photo—4.30 Precast concrete slab

7) Bomyatun Bridge

The Bomyatun Bridge is a truss bridge completed in 1999 over a branch river of the Irrawaddy on the Yangon-Pathein road, and was Myanmar's longest bridge at the time (Photos 4.31 & 4.32).



Photo-4.31 Bomyatun Bridge



Photo-4.32 Bomyatun Bridge

Though the 2010 survey detected rust at the truss panel points (Photo 4.33), no other degradation damage was found.



Photo—4.33 Rust at the panel point of the truss

In the 2011 survey, since damage was detected in some of the asphalt pavement surface, looking at the underside of the slabs revealed evidence of repair to the slabs (Photos 4.34 & 35).



Photo—4.34 Damaged asphalt pavement



Photo—4.35 Remnants of repairs to concrete slabs

8) Yar Yamaung Bridge

The Yar Yamaung Bridge is a single-span suspension bridge completed in 1999 (Photo 4.36).



Photo—4.36 Yar Yamaung Bridge

Due to the low traffic volume over this bridge, even though there are two lanes, most vehicles drive down the center of the road which has caused the molded steel of the road surface to become deformed (Photo 4.37). It would be preferable if small blocks (chatter bars in Japan) were installed along the center line to ensure the traffic to keeps the two-lane system.



Deformation of steel deck

Photo 4.38 shows what appears to be a cement mortar coating to the main cable. The same kind of material was used on the Myaunmya Bridge in the Irrawaddy region surveyed

in 2010. It was a surprise such a low quality coating was used in this bridge also. We thought the Myaunmya Bridge was an exceptionally low quality suspension bridge because of the very first suspension bridges built in Myanmar.

The coating of the cable has split, been chipped away, and corrosion can be seen on the exposed inner section of the cable. From the condition of the cable corrosion, the cable may not have been corrosion proofed (Photo 4.39).



Photo—4.38 Main cable cladding



Photo—4.39 Splitting and erosion of main cable cladding

9) Da let-Chaung Bridge

The bridge is a Bailey Bridge constructed in 1999, and is currently under repair since flooding washed away a pier in 2011 (Photo 4.40).

It appears that the open-caisson foundations were insufficiently embedded into the soft rock of the river-bed, and the pier was washed away due to scour.

In order to avoid similar future trouble occurring due to flooding, once the cause has been sufficiently investigated the bridge should be reconstructed, and measures to prevent scour of the remaining piers may also be required.



Photo—4.40 Da let-Chaung Bridge under repairing

10) Aungzaya Bridge

The Aungzaya Bridge crosses the Hlaing River that flows through western Yangon and was completed in 2000. It is a four-lane cable-stayed bridge with steel girder trusses, and has a central effective span of 300m (Photo 4.41).



Photo-4.41 Aunzaya Bridge



Photo-4.42 Rust due to drain water from the road surface



Photo-4.43 Rust due to drain water from the road surface



Photo-4.44 Precast concrete slab

A drainpipe runs through the trusses from the road surface, but only extends partway (not clearly shown in the photos). Therefore drainage water runs over the trusses causing rusting (Photo 4.32 & 43). When maintaining the bridge, careful consideration at the level of design and construction is required.

The slab uses reinforced concrete precast slabs (Photo 4.44).

In Myanmar, due to the strict construction period required, precast slabs are used on-site instead of cast-in place reinforced concrete slab. At present no signs of deterioration such as joint leakage has been found, though the design and detailed structure requires investigation.

Cracks in the surface of the concrete bridge railings were seen (Photo 4.45). Since these

cracks were of a pattern commonly seen with alkali-aggregate reactions, it is suggested that the alkali causing the reaction is investigated.

In the rear face of the abutment, cracks such as in Photo 4.46 were seen. It is suggested follow-up observation is required.



Photo-4.45 Cracks in the bridge railing



Photo-4.46 Concrete cracks

In April 2011, advice was requested by mail in relation to a damaged expansion joint on the Aungzaya Bridge, and an investigation was carried out in 2011.

A Chinese manufactured expansion joint (an imitation of a German Maurer joint) had been used, and as shown in photos 4.47 & 48, most of the beams have fractured and support beams have simply been loaded on top, and then the beams have jumped out with the passage of traffic above.

The damage has clearly worsened since PW requested repair advice in April 2011. The fractured beams have fallen on the top of the pier, and timber has been put in the vacant space (Photo 4.49).

The site was inspected in June 2011 also, and it was advised it was in a state that would not be left for even a day longer in Japan. Even though it was suggested that at the very least the damaged sections of the joints should be covered with steel plating, and that traffic should be instructed to drive slowly, no action had been taken by the time of the 2011 study in December that year (when this was suggested again in the 2011 study, the damaged sections were finally covered with steel plating).

Note that, the same type of expansion joint as used in this bridge was purchased from China and used in many other truss bridges, and particular care must be taken when performing maintenance.



Photo-4.47 Damage to an expansion joint



Photo-4.48 Fractured member of expansion joint



Photo-4.49 Fractured member of expansion joint
dropped on the top of the pier

11) Mahar Bandoola Bridge

The Mahar Bandoola Bridge was completed in central Yangon in 2000, and is a six-lane cable-stayed bridge with a central effective span of 130m (Photo 4.50). Steel trusses were used in the stiffening girders.



Photo-4.50 Mahar Bandoola Bridge



Photo-4.51 Wound cable rubber guard

Photo 4.51 shows the attachment zone to the stiffening trusses of the cable. A rubber guard has been wound around the attachment zone to prevent rainwater seepage; however it has a major fracture and is not fulfilling its essential function.

The concrete slabs of the approach concrete bridge (Photo 4.52) have been damaged several times a year over the past few years. Photo 4.53 shows the repairs to the slabs. When examining the cause of the damage to the slabs, necessary countermeasures need to be investigated.



Photo-4.52 Approach concrete bridge of Mahar Bandoola Bridge



Slab damage due to Heavy truck in Bandoola bridge



Photo-4.53 Slab under repairing

12) Shwe Pyithar Bridge

The Shwe Pyithar Bridge is a four-lane truss bridge completed in 2001 and crosses the highest reaches of the Hlain River (Photo 4.54).



Photo—4.54 Shwe Pyithar Bridge

No major deterioration damage was seen in the superstructure of this bridge, though the main members of the truss and panel points have rusted (Photo 4.55 & 56).



Photo-4.55 Rust of the truss



Photo-4.56 Rust of the panel point

There were sections of untended damage to the expansion joint (Photo 4.57).

At the slab of the approach concrete bridge, due to shortening the construction period, a left-in-place material precast concrete formwork has been used on the underside of the slabs (Photo 4.58).



Photo-4.57 Damaged expansion joint



Photo-4.58 Slab of an approach concrete bridge

13) Min Chaung Bridge

The Min Chaung Bridge is a truss bridge that spans a channel of the eastern Sittwe marshes (Photo 4.59).



Photo—4.59 Min Chaung Bridge

From looking at the surroundings, no doubt it is difficult to obtain a large quantity of freshwater, and it appears seawater was used when mixing concrete during the construction of the bridge. Of course it is thought unwashed sea sand was used as the construction material.

A large quantity of concrete has peeled away from the concrete pier and the rebars have become exposed and fractured (Photo 4.60). Due to major peeling of the concrete, one section has fallen off and smashed (Photo 4.61).



Photo-4.60 Damaged concrete pier



Photo-4.61 Fragments of peeled off concrete around a pier

The rebars of the peeled insides have corroded and turned a black-red color which is a characteristic of salt damage (Photo 4.62).

Part of the concrete pier has been reinforced using concrete lining (Photo 4.63).



Photo—4.62 Rebar corrosion and concrete covering



Photo—4.63 Strengthening of the piers of the Min Chaung Bridge using concrete lining

Looking at the corrosion of the steel members, the whole bridge continues to corrode, and pitting corrosion that gouges deep into the member can be seen. The rust that fell when cleaning the surface for repainting (Photo 4.64) is characteristic of salt damage, and paint film degradation and steel corrosion due to airborne salt and salty air were confirmed (Photo 4.65).



Photo-4.64 Repairing work (within the circle are workers using only a safety rope)



Photo-4.65 Fallen rust fragments

Not only is the number of coats applied in the repainting insufficient, with just one coat each of primer and anti-corrosive paint, (four or more coats are standard in Japan), but the anti-corrosive paint also appears to be one of low-quality that has been discontinued in Japan, and long service cannot be expected in this environment of salt damage.

There is also no quality control of the paint used for the paintwork, which it seems is simply painted on with no essential pre-painting survey or control of film thickness. Such a method will require another repainting sooner or later, and each repainting weakens and significantly reduces integrity of steel member.

14) Lonedawpauk Bridge

The Lonedawpauk Bridge is one of ten bridges constructed in the Kyaukphyu region of the Yangon-Kyaukphyu road completed in 2004. All are of the same design including the Min Kyaung Chaung Bridge.

This is an area where obtaining a large quantity of freshwater is no doubt difficult and it is thought seawater was used in concrete mixing. The execution of the concrete is also not good (Photo 4.66 & 67)



Photo—4.66 Underside of an approach concrete bridge's walkway



Photo—4.67 Cross beam of an approach concrete bridge

As seen in Photo—4.68, deterioration of slab has been already started.



Photo—4.68 Depression in a road surface due to damaged slabs

Looking at the corrosion of the steel members, as can be seen in photos 4.69 & 70, peeling of the paint film on the truss members can be seen over a wide area. Peeling of the paint film suggests that the paint itself has low adhesive properties, and the cause of the peeling requires investigation since the total destruction of paint film is regarded as a warning.

In some areas of peeling the film thickness is less than half, and since the anti-corrosiveness of those areas is greatly reduced, repainting (recoating) is urgently required as soon as the cause of the peeling is found.



Photo-4.69 Peeled paintwork of the truss

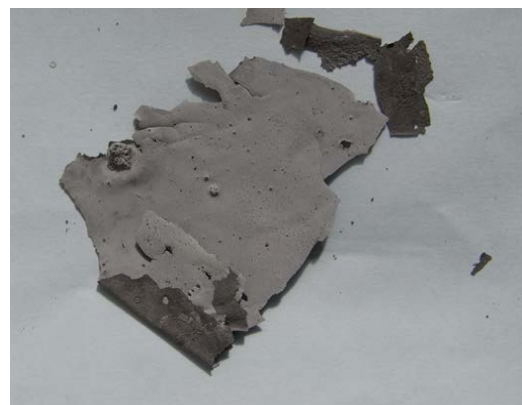


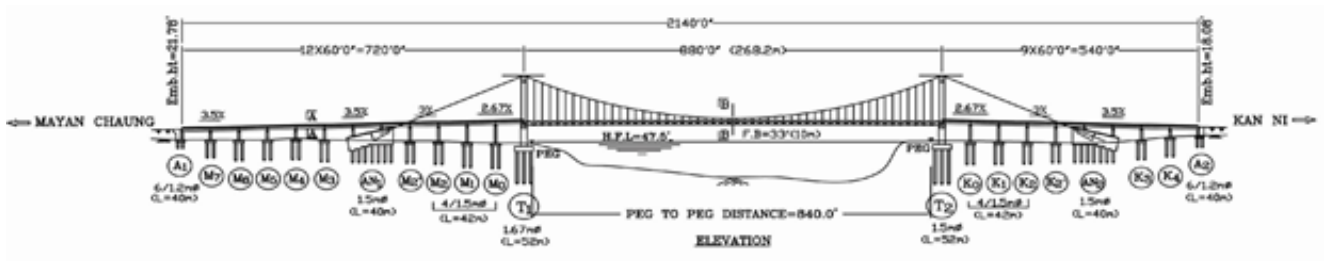
Photo-4.70 Peeled paint film

15) Pathein Bridge

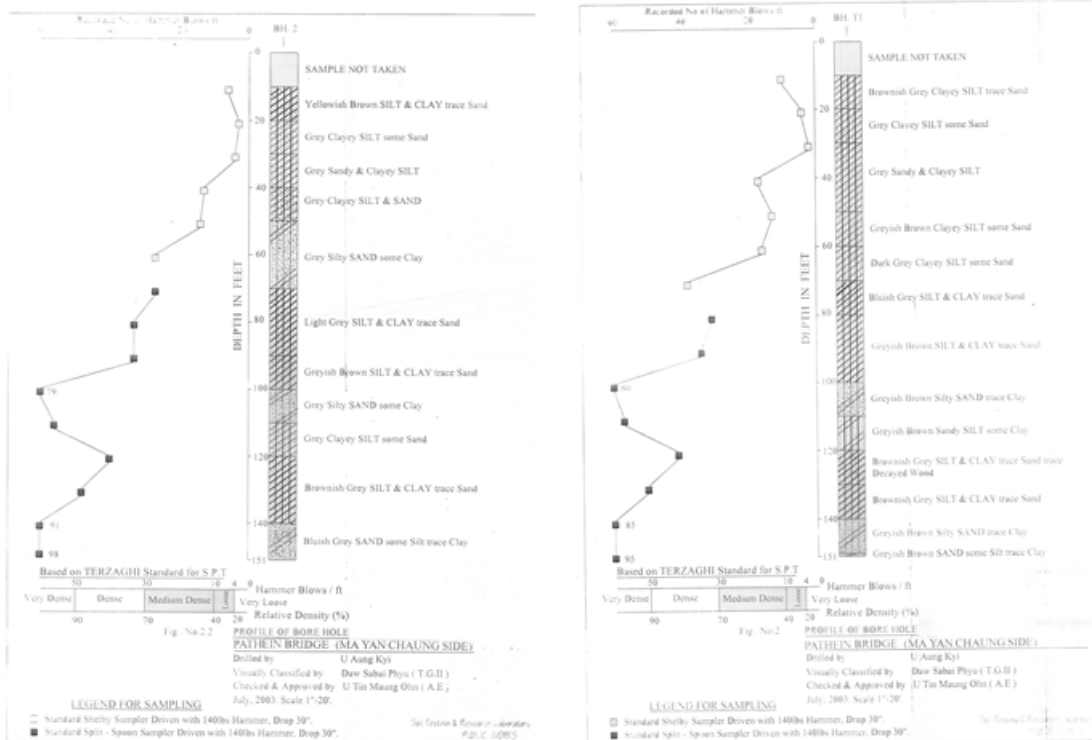
The Pathein Bridge constructed in 2004 is a suspension bridge of a similar scale to the Twantay Bridge manufactured by the same Chinese manufacturer (Photo 4.71, fig. 4.6 & 7).



Photo—4.71 Pathein Bridge



图—4.6 General view of Pathein Bridge



Figure—4.7 Boring log of Pathein Bridge

Almost exactly the same problem was found on the Twantay Bridge constructed in 2006.

In addition, fractured high-tension bolts due to what was believed to be delayed fractures were seen not infrequently (Photo 4.72). It is suggested that in order for future countermeasures to be taken, bolt quality should firstly be tested, and the bridge's manufacturer should be informed to consider future countermeasures.



Photo-4.72 Deficit of bolt at truss splice plate

Looking at the corrosion of the steel members, water is moving around inside the material of the main cable wrapping, and a water channel can be seen in the underside of the cable (Photo 4.73). When such phenomena occur, it is highly likely that internally the cable wire is corroded. The diagram notes no materials for corrosion proofing, and it is possible that the protective layer is of inferior quality.



Photo-4.73 Water trace at main cable lapping

Corrosion in the protective layer of the hanger can also be seen (Photo 4.74). While the protective layer used fiber reinforced polymer (FRP) concrete, it is coming away and breaking and requires urgent repair.



Photo—4.74 Breaking and peeling of the hanger's FRP covering

16) Min Kyaung Chaung Bridge

The Min Kyaung Chaung Bridge was completed in 2006 (Photo 4.75).



Photo—4.75 Min Kyaung Chaung Bridge

Since seawater was apparently not used in the concrete mixture for this bridge, the concrete of the piers, etc., is relatively sound.

However, as for the concrete slabs of the truss section, as shown in photo 4.76, the covering concrete of the concrete precast slabs used for the underside of the slabs is falling away. This is thought to be because seawater was used in the manufacture of the precast slabs.



Photo—4.76 Damaged precast concrete slabs

Photo 4.77 is an image that explains the repair work to damaged slabs.

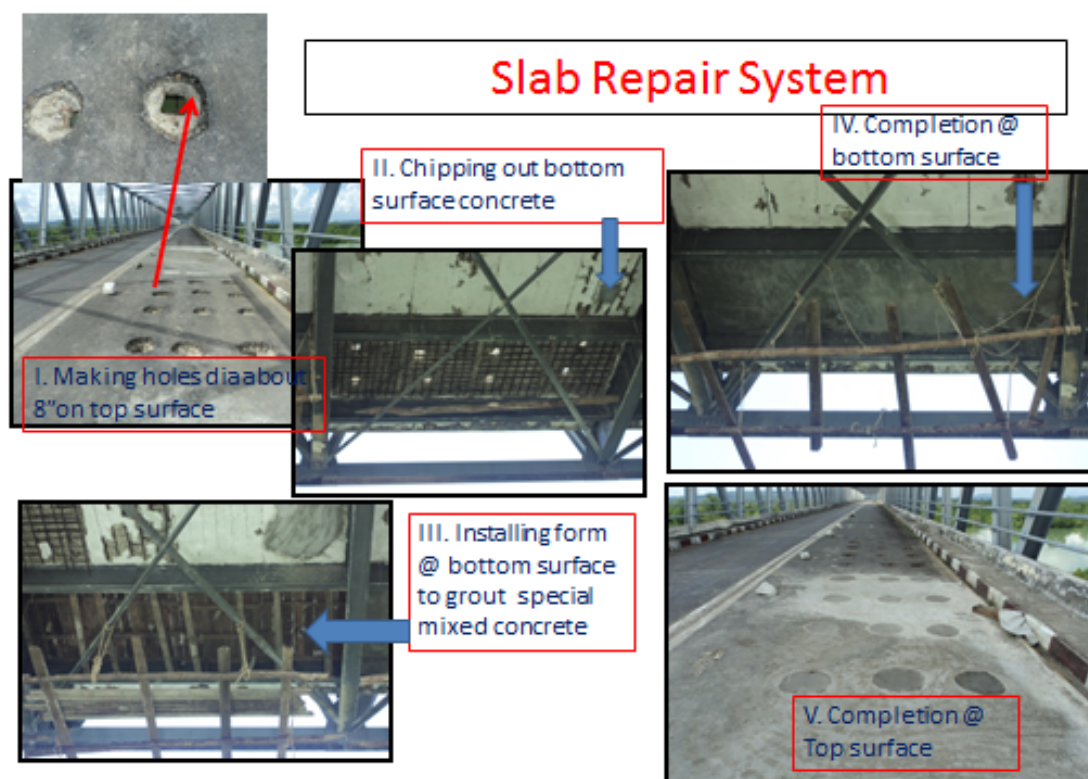


Photo-4.77 Explanation photos for slab repair work

It appears that the precast slabs have been removed, and the concrete of the underside of the slabs has been replaced, but for reasons entirely unknown, many holes have been made in the road surface.

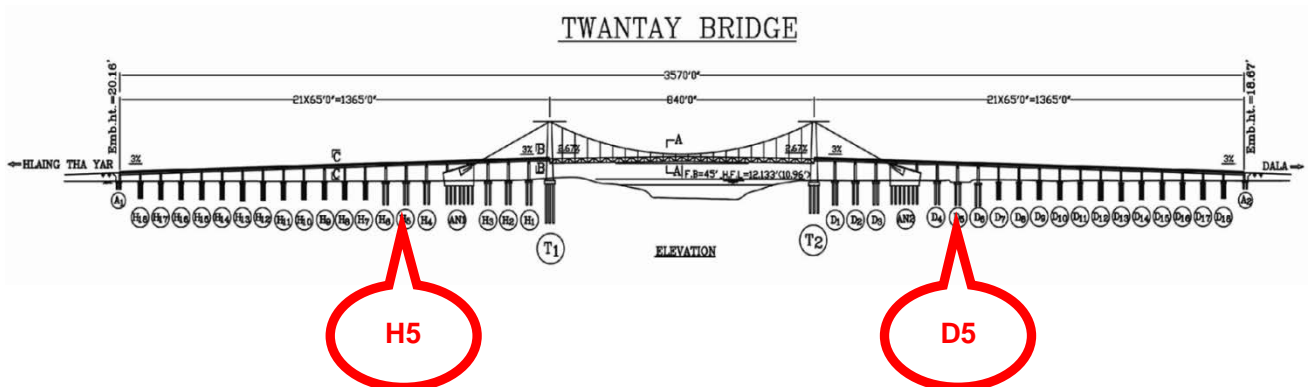
This type concrete slab was first used in some truss bridges including the Kaungkong Bridge over the Yangon-Pathein Road which was improved with Swiss assistance (See P.11). In this design, tensile longitudinal rebars have been placed in the concrete precast slabs underside of the slab which is a design that deviates from the fundamentals of reinforced concrete.

17) Twantay Bridge

The Twantay Bridge constructed in the Yangon suburbs in 2006 is a single-span suspension bridge of almost the same scale as the Patheingyi Bridge constructed in 2004. The superstructure was purchased from a Chinese manufacturer (Photo 4.78, fig. 4.8).



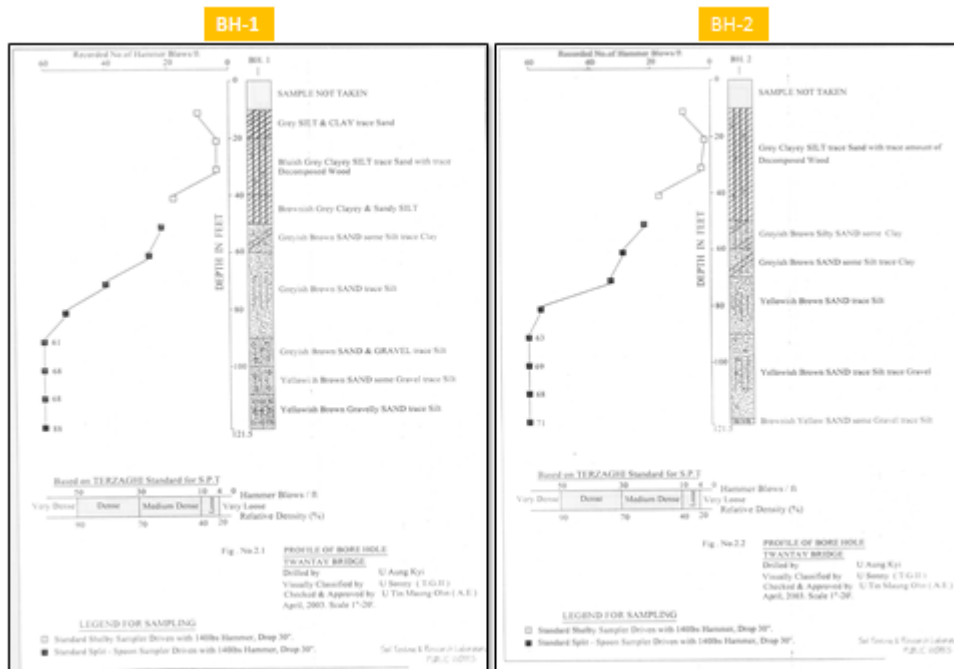
Photo—4.78 Twantay Bridge



Figure—4.8 General view of Twantay Bridge

This region has soft alluvial ground as shown in Figure. 4.9.

This suspension bridge has lost a great deal of camber since completion, and in the 2010 study it was suggested that because the anchorage has simply been laid on the cast-in-place concrete piles (diameter of 1.2m), the horizontal force of the main cable may move the anchorage forward.



Figure—4.9 Boring log of Twantay Bridge

From looking at the ground surface layer surrounding the anchorage (Photo 4.79), the gap of the expansion joint of the approach concrete bridge (Photo 4.80), and the concrete peeling off the cross beam of the pier below (Photo 4.81), the change in camber is believed to be mainly due to the movement of the anchorage.

The behavior of the suspension bridge needs to be measured urgently, and depending on the results, countermeasures may be needed to prevent the anchorage from moving.



Photo-4.79 Gap between the main tower and the ground behind



Photo-4.80 Gap of expansion joint 5



Photo—4.81 Concrete peeling of the cross beam of the H5 pier

As indicated in photo 4.82, the hanger rope and truss top chord are joined with bolts, though the bolt-heads are corroding. It is suggested that drainage holes are urgently bored in the truss and the bolts are anti-corrosion proofed (it was also suggested in the 2010 survey to bore drainage holes, though this has not been implemented).

Similarly, as shown in Photo 4.83, the truss top chord is seriously corroded, so it is suggested that similar anti-corrosion proofing is required, and a creasing structure (water cutting structure) is proposed for the underside of the end of the slabs.



Photo-4.82 Corrosion of the hanger rope attachment



Photo-4.83 Corrosion of the top truss chord

18) Dagon Bridge

The Dagon Bridge completed in 2007 is a six-lane concrete Gerber bridge of a total length of over 800m which spans the Bago River in eastern Yangon (Photo 4.84 & 85).

This is one of the few long-span concrete bridges because Myanmar has strict demands in relation to construction periods. There were also problems in providing cement and it took 7-8 years to complete. A mainline to connect the new port and new industrial zone in central Yangon and eastern Yangon is under construction, though it is thought because the Thanlyin Bridge described above is located slightly downstream, only a low volume of traffic is expected for the time being, and hence a concrete bridge was adopted.

There are fears that damage will appear in the near future as the Gerber construction has multiple expansion joints which will vibrate severely with the passage of heavy trucks.



Photo-4.48 Same type bridge as Dagon Bridge



Photo-4.85 Still less traffic

19) Tha Yu-Pa - PA done Bridge

Photo 4.86 shows a newly completed suspension bridge in the suburbs of Ann City.



Photo—4.86 Tha Yu-Pa - PA done Bridge

Though it is small-scale, it is of PW's own design and was constructed of ordinarily available materials with the exception of the main cable which was purchased from a Chinese manufacturer.

However, the cable appears to have been coated using the same cement mortar as the Myaungmya Bridge over the Irrawaddy.

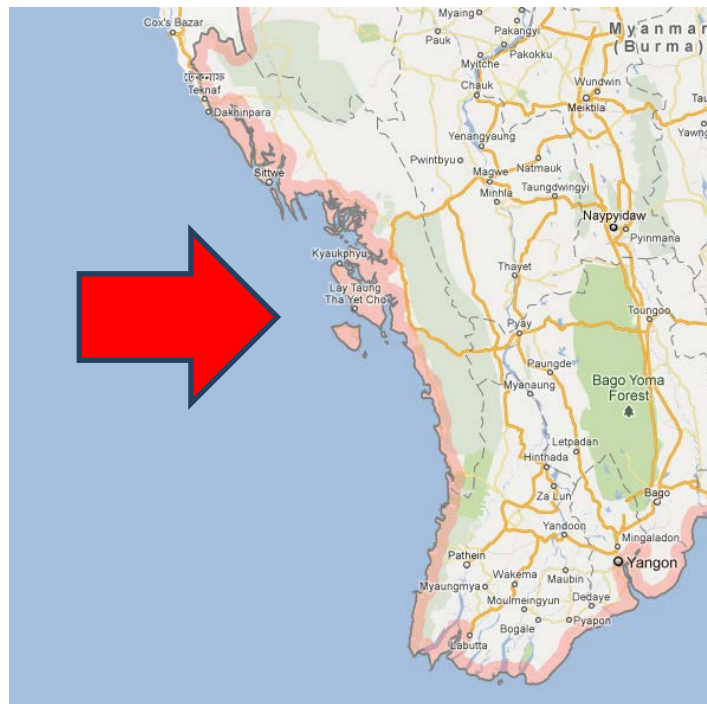
Similarly, the molded steel surface used for the bridge slab has no checkers (hatched markings), and it is feared that 2-wheeled vehicles may slip (checkers are generally used on this kind of molded steel bridge slab, but apparently it just happened that none were available when this bridge was constructed. Perhaps this was due to the strict construction period).

5. Main issues

1) Salt damage to concrete

Along the Bengal coast of Rakhine Region, the westerly wind from the Bay of Bengal brings high-temperatures and humidity and so concrete structures sustain remarkable salt damage.

However, in addition to such unfavorable conditions, the lack of basic measures against salt damage to concrete cannot be overemphasized.



Figure—5.1 Bengal Bay in Myanmar

More specifically, on the islands off the coast in this region, securing a large volume of freshwater is difficult so it is thought that not only has unwashed sea sand been used, but seawater has been used to mix concrete in parts of the site. Needless to say, if seawater is used to mix reinforced concrete, there will be significant salt damage to the concrete. Use of seawater must be totally prohibited.

Likewise, if using sea sand, it must be washed in freshwater as a rule. If washing sea sand is difficult due to difficulty in securing a large volume of freshwater, a mound of sea sand should be sufficiently exposed during the rainy season and then used when the top layer of sand is confirmed to be below the standard level of salt concentration

Similarly, when designing with reinforced concrete, while it is only natural that sufficient

concrete covering must be secured, it is also necessary to consider introducing anti-corrosive technology such as rebars with epoxy paint.

At any rate, the reality that seawater has been used to mix concrete must be faced, and strict approaches to counter salt damage to concrete are essential.

Similarly, concrete structures that are already seriously salt damaged must urgently be repaired and reinforced.

While it appears that some repair work is already underway, such work should not be carried out based on the judgment of individual supervisors, but must be approached through the organization of the PW.

2) Design of concrete slabs for bridges

In Myanmar, precast concrete panels are often used for the slab of bridges due to workability and short constructed periods.

These are shown below.

Type I is commonly used in concrete girder bridges (Photo 5.1, fig. 5.2). It uses precast panels only as formwork, and precast panels are ignored in the calculation of cross sectional strength. In this case, the cast-in-place concrete slabs are six inches thick, and it is feared that the cross-sectional thickness is insufficient depending on loading conditions.



Photo-5.1 Slab of concrete girder bridge (Type I)

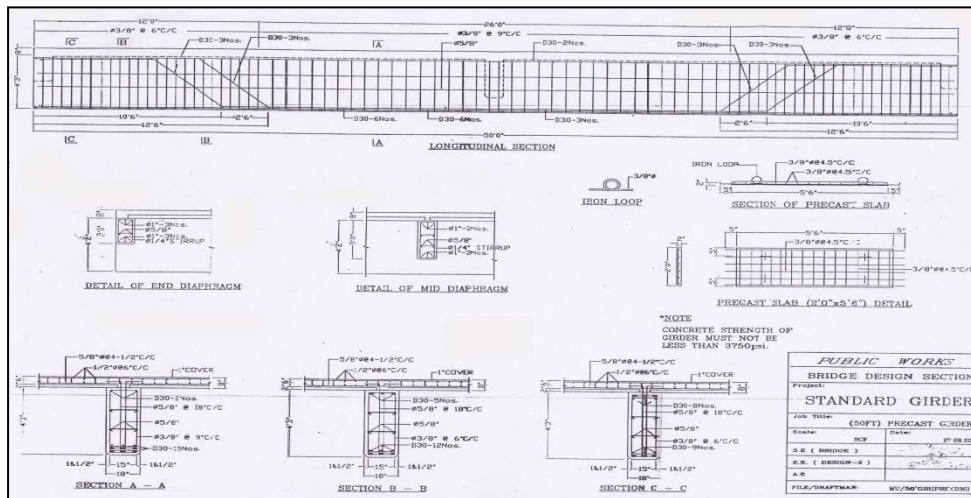


Figure-5.2 General view of Type I

This type of slab is used on the Mahar Bandoola Bridge which carries a high volume of traffic within Yangon City, and apparently slabs have been falling frequently in recent years.

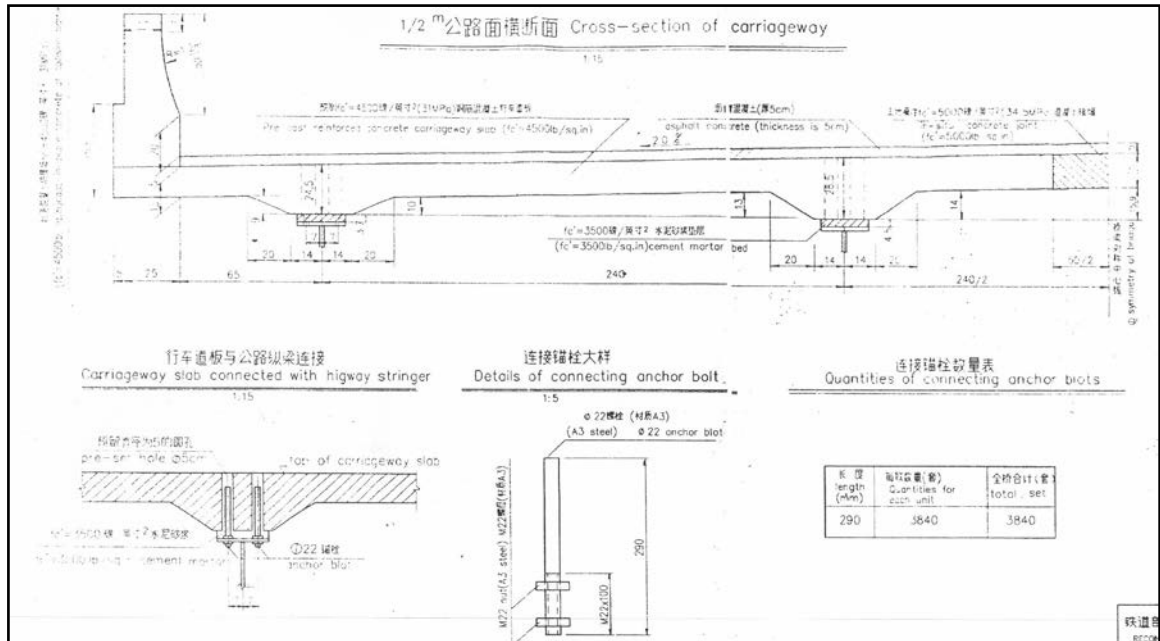
Type II is a precast slab with ribs attached and is used on the Bayinaung Bridge (Photo 5.2). It is of sufficient rigidity and no anomalies were seen in the joints, etc.

The trusses for this bridge are made by an Italian manufacturer, and this bridge is the only bridge using this type of slab.



Photo-5.2 Slab of Bayinaung Bridge (Type II)

Type III is a precast slab which is used on most truss bridges by Chinese manufacture and also by Japanese corporations (Fig. 5.3, photo 5.3).



Figure—5.3 General view of Type III slab



Photo—5.3 Precast slab of a general truss bridge (Type III)

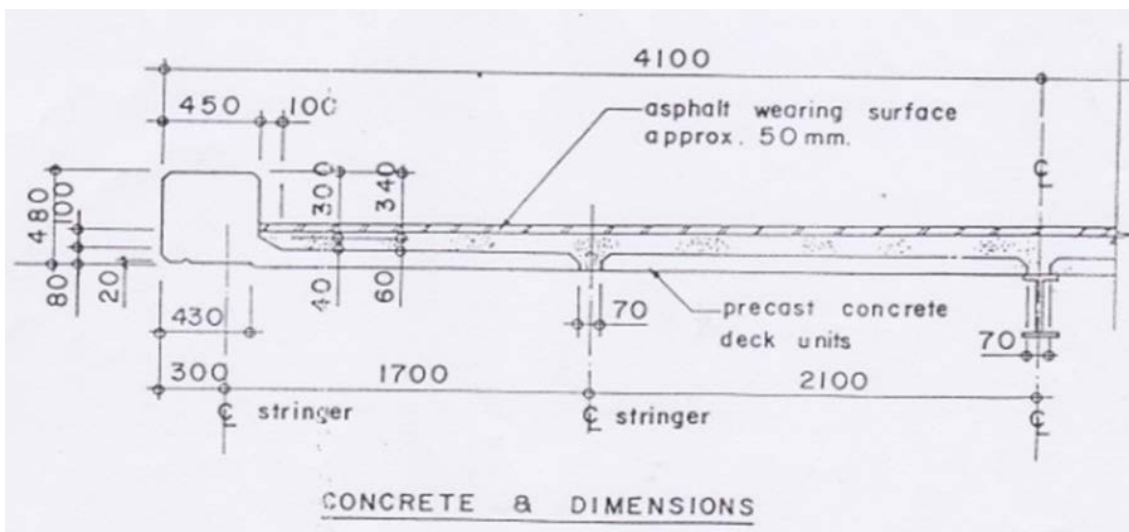
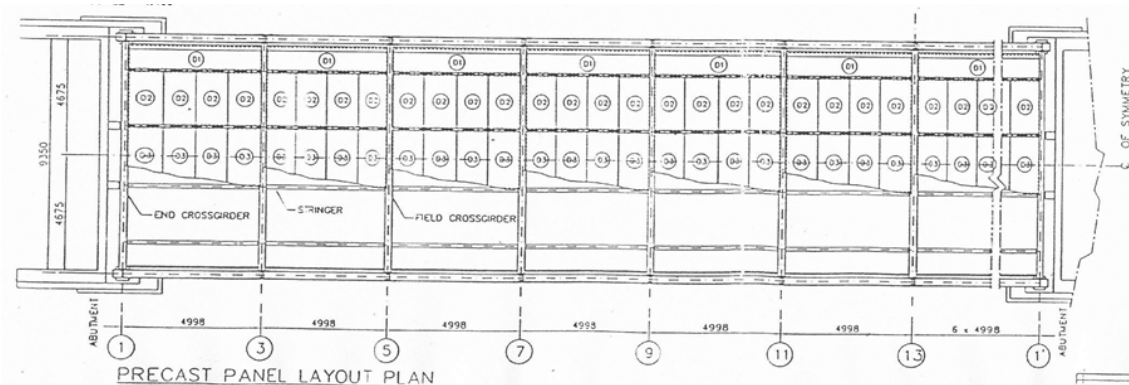
While there are concerns over the durability of the cast-in-place concrete joints (prestress is not introduced) of the precast slabs, currently no signs of deteriorated joints have been seen.

However, since there are concerns that the joints will be damaged in the long-term, at some point it is thought countermeasures must be considered.

Type IV is the slab used in a small-to-midsize truss bridge when the Yangon-Pathein Road was improved with Swiss assistance in the 1980s (Photo 5.4 & fig. 5.4).



Photo—5.4 Type IV slab



Figure—5.4 General view of Type IV slab

This slab is composed of cast-in-place concrete on top of precast panels arranged on the cross beam of the truss floor system; however, the precast panels contain tensile longitudinal rebars.

Looking at the design documents, it became clear that the designer had no understanding whatsoever of the principles of reinforced concrete. The explanation of the design of the slabs is as follows.

All panels are reinforced with S16 bars and with 25 mm clear bottom cover. The outer panels are designed for a kerb edging to be cast with the slab.

It is considered that a 25% increase in permissible loads is acceptable under the combined action of the above loads for construction conditions. The effective span length is taken as the clear distance between supports plus the depth of panel, as given by AASHTO Article 8.8.

If the applied moment for the inner slab panel is less than the uncracked moment capacity of the section, provision of nominal reinforcement, central within the slab, is satisfactory. Stress in the reinforcement for the working load condition is negligible, however, the reinforcement is taken into account in the ultimate condition giving a load factor against collapse.

In similar manner, the outer panels are found to have a moment due to total load which is less critical for the internal panels.

The permanent deflection of the simply supported precast panels may be calculated from elastic theory since the sections remain uncracked. It is considered acceptable if the deflection is less than the span divided by 2400.

If no cracks appear in the concrete, the rebar stress created by ordinary loading would be very small. It has to be said that the design deviates from the principles of reinforced concrete.

There has also been no consideration of the integration of the precast plates and cast-in-place concrete.

The PW engineers feel the manufacturer is partly responsible for the superstructure of the slabs, and did not have doubts about the design.

However, regardless of how it was designed, the vehicle load is currently low, and because no tension cracks have appeared in the concrete, there are no particular visible abnormalities.

Since there is currently no visible damage, it is difficult to take countermeasures, but if the volume of traffic and heavy vehicle traffic increases, life-threatening damage will certainly occur, and some kind of action is required.

Concrete slabs designed in the same way are used on ten truss bridges on the Yangon-Kyaukphyu Road in the Kyaukphyu region (this method was also adopted for the approach concrete bridges within this group of bridges). However, seawater was used in the concrete of the precast members in this region, so the rebars in the precast members have corroded and the underside of the concrete started to fall away, and serious damage to the slabs has already occurred.

It is thought there is no better repair method than to replace the single-piece cast-in-place reinforced concrete slabs.

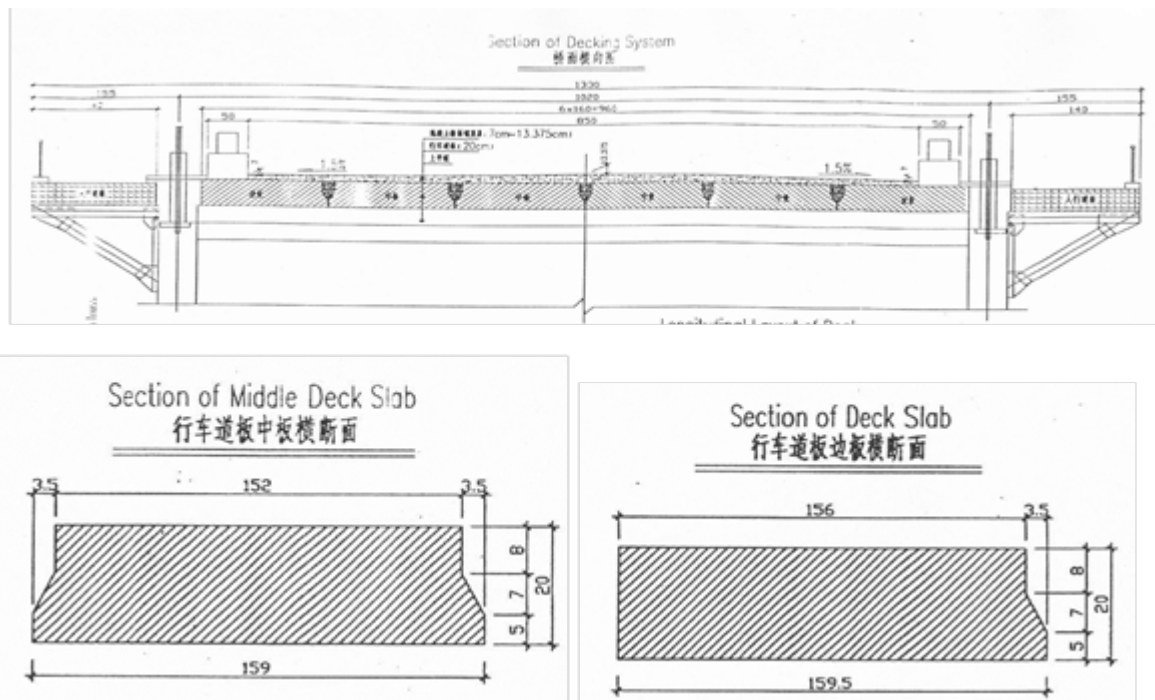
(This was revealed after leaving Myanmar from available data that this type of slab was used on an approach concrete bridge of the Maubin Bridge designed in 1996. That means

apparently this type of concrete slab is used rather extensively in Myanmar).

Type V is used in suspension bridges of relatively recent construction, and is a longitudinal precast slab supported by the crossbeam of the stiffening trusses as (Photo 5.5, fig. 5.5).



Photo—5.5 Type V slab



Figure—5.5 General view of Type V slab

At present it appears to be in a sound state, with no anomalies seen in the longitudinal masonry joints of the precast slabs.

However, the way of calculating the cross-sectional force of the design needs to be verified since the effective span length of this concrete slab is greater than general flooring.

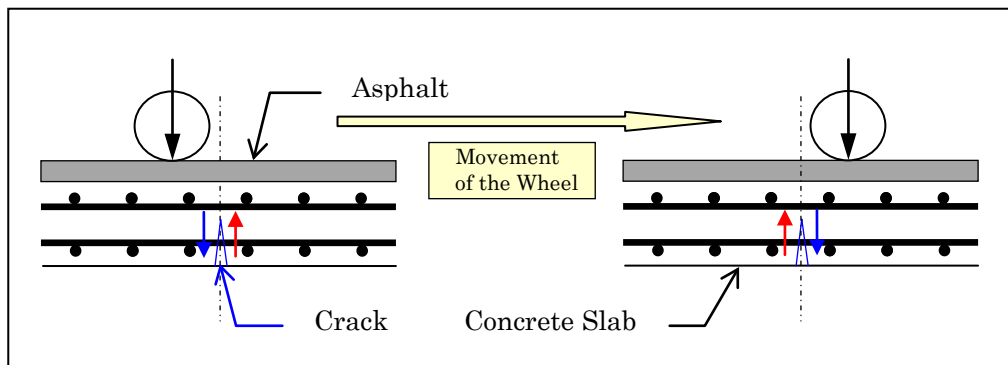
Above, each type was described, and Type IV needs to be discontinued immediately, and there are also doubts about any future usage of Type III.

At any rate, the design of the concrete slab of bridges should not be left to the bridge manufacturer, and since damaged slabs present an immediate obstacle to traffic. PW must make a concerted effort to address the challenges of the future design, construction, maintenance and repair of concrete slabs.

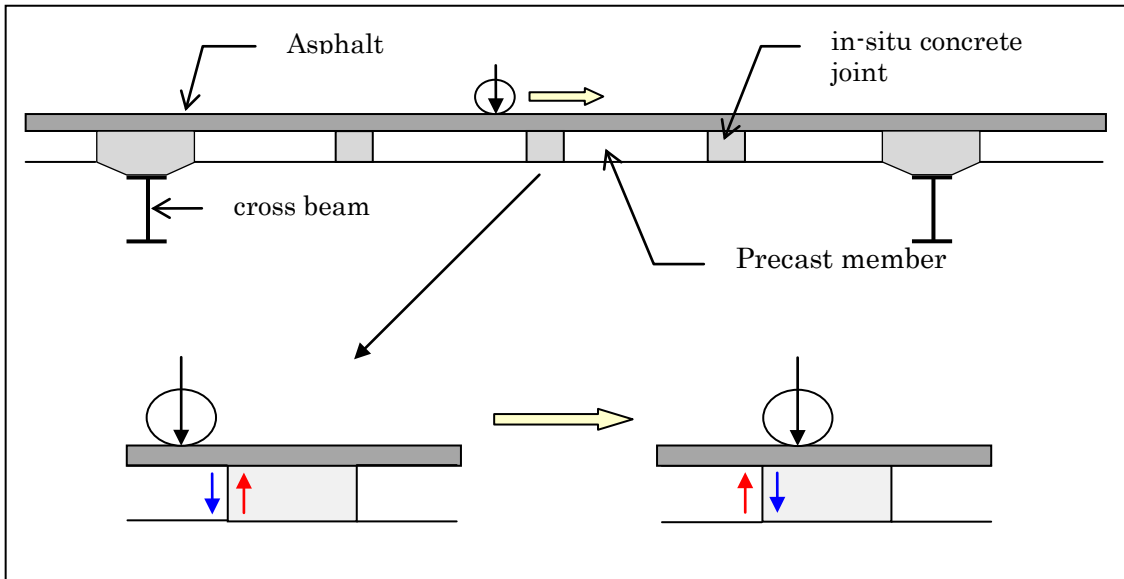
The fundamental thinking on the deterioration of bridge slab is as below

The damage to the concrete slab is caused by alternating shear stress by repeated wheel loading exerted on the concrete cross-section in which the cracks occur (Fig. 5.6), and the concrete in-situ joint of the Type III slabs is at risk of damage for the reasons described (Fig. 5.7).

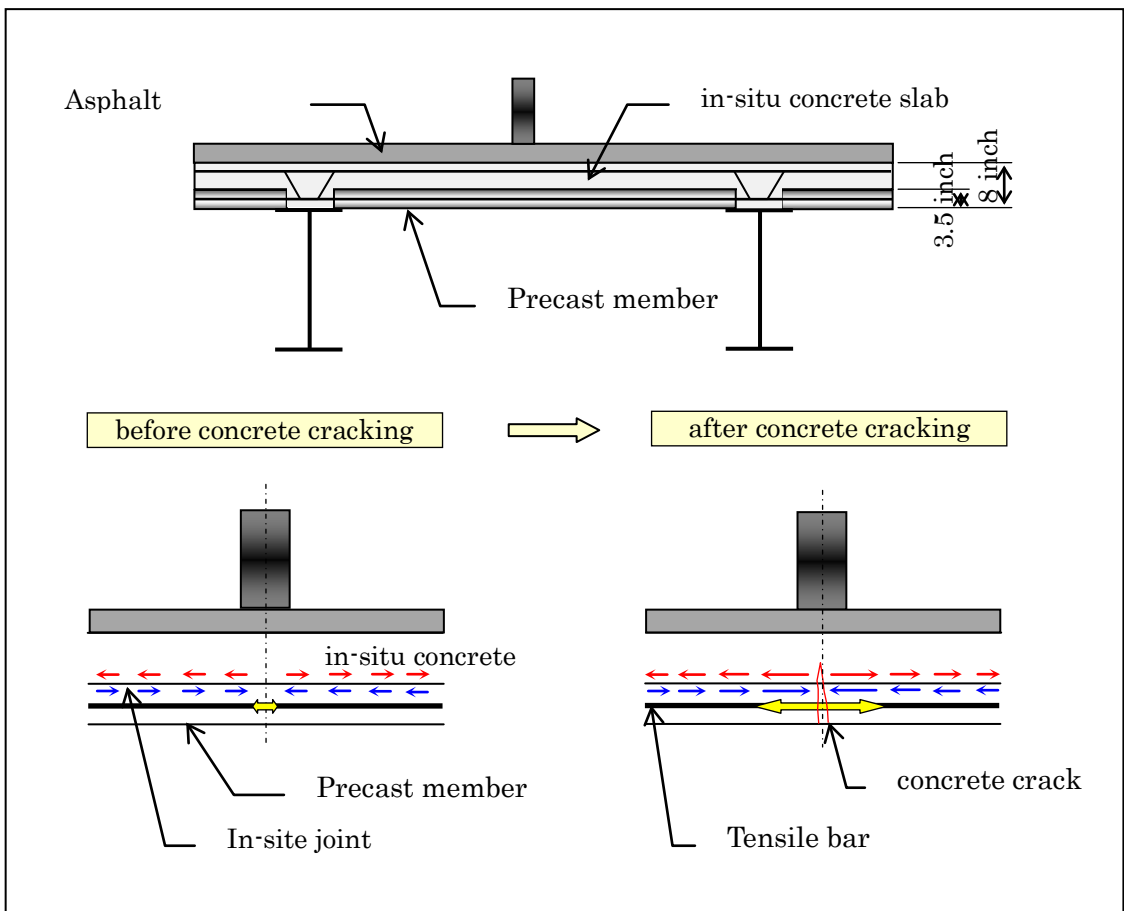
With the Type IV slabs, when cracks appear in the concrete, major stress is exerted on the face between precast panel and cast-in-place concrete and the bond between them must be damaged by the repeating traffic load, and the integrity of the precast panel and cast-in-place concrete is lost and it is no longer able to function as slab (Fig 5.8).



Figure—5.6 Cause of the deterioration of concrete floor slab of the bridge



Figure—5.7 Deterioration of the in-situ joint of a Type III slab



Figure—5.8 Deterioration of the in-situ joint of a Type IV slab

Note that in Japan, to prevent damage to concrete bridge slab due to vehicle loading, the level of allowable stress on rebars is set lower than other structures to prevent major cracks appearing in the concrete, and regulations are in place stipulating that slabs should be of minimal thickness to minimize shear stress on concrete.

3) Movement of bridge substructures on soft ground

Table 5.1 is a timeline of cases of bridge substructures thought to have moved atop soft ground.

Table—5.1 Case where a bridge's substructure is believed to have moved due to soft soil

No	Bridge	Completion
1.	Thakhut Bridge	1991
2.	Bayinaung Bridge	1994
3.	Myaungmya Bridge	1996
4.	Maubin Bridge	1998
5.	Pathein Bridge	2004
6.	Twantay Bridge	2006

Case 1 is an early phase concrete bridge that PW constructed after BETC, and the abutment was moved during construction due to the embankment at the rear face of it and also the pier was moved by the change in the height of the river bed. In cases 2 & 4, the abutment on the soft ground moved forward due to earth pressure on its rear face and had negative effect on the truss bridge, and cases 3, 5, & 6 are cases where the anchorage of a suspension bridge is believed to have moved due to horizontal force by the main cable.

In other words, in Myanmar, regardless of the numerous experiences of substructures moving easily atop soft ground due to horizontal force, almost no action has been taken.

During the current study, we were able to make the PW engineers realize that bridge substructures move easily on soft ground. In particular, if the movement of a suspension bridge's anchorage does not stop, there is even a risk of bridge collapse.

Likewise, in the wide-ranging area of the Irrawaddy delta, countermeasures against the soft ground are a major issue for the PW engineers who are attempting to build a road network of over 800km in this region to respond to Cyclone Nargis.

4) Repairs to the expansion joints and shoes of bridges

Most of the damage to the expansion joints and shoes of bridges were thought due to the

movement of the bridge substructures. It is thought that the expansion joints and shoes, aside from whether they are functioning satisfactorily can be reused, as many are made from relatively sound materials. However, it is difficult for the PW staff to investigate repair methods since there are no bridge general views or design calculations which are required when considering repair designs. Though currently there are few engineers related to repair because efforts are still directed to construction, it is thought emphasis must be put on acquiring repair skills so that the same damages do not recur. Similarly, regarding each type of repair work, it is thought that the details of repairs must be recorded so that a response can be taken when the same kind of damage appears. Bearing in mind that infrastructural improvements are progressing, and that Myanmar is entering an age where bridges will be increasingly extended and continue to age, it must be recognized that a database needs to be built to record the various bridge specifications and details of repair works.

The Chinese manufactured expansion joint installed on the Aungzaya Bridge has been used on many long-span bridges that were designed in China such as the Maubin Bridge, and the design details of this expansion joint are not understood. It was recommended bridges installed with this expansion joint should have the device replaced with a finger joint because PW can understand the structure and domestic manufacture is possible.

The design calculations for the bridge design are based on Japan's standard for bridge design, and PW also has the design materials for part of the finger joint (though apparently they have never calculated it themselves), and it is thought with experience they will become able to design expansion joints. However, PW has no experience of repair work to replace expansion joints, and it is hoped that they can receive guidance while referring to cases of repair work performed in Japan.

Regarding bridge shoes, damage to the Maubin Bridge's locker shoes and rubber shoes was seen, and damage was also seen on all shoes where displacement in a horizontal direction exceeding the anticipated change in position had been applied to the main body of the shoe. When changing bridge shoes such as the locker shoes of the Maubin Bridge, it is thought that replacement by jack-up is common, but the reinforced structure of the girders and jacking-up process must be sufficiently understood before this is carried out. In particular, with concrete girders, if it is not jacked-up simultaneously and equally, the main bridge may be damaged. It is hoped that technical support will also be provided with such repair work.

5) Bridge paintwork

It is common knowledge that the paint on coastal steel bridges is susceptible to damage from the salty air. In Myanmar, in terms of damage to steel bridges, corrosion of the overall

bridge is seen within ten years, and the need for repainting is pressing.

However, if repainted using the same poor quality paint, it makes matters worse. Paint with a superior anti-corrosive effect must be adopted.

One of the reasons for the early deterioration of paintwork is the problem with the quality of bridge paint. There are many reasons why the paintwork is of poor quality, including the lack of reliable specifications, poor quality paint, defective execution, and the inadequate system of acceptance testing and inspection.

Looking at the paintwork of the steel bridges in Myanmar, the reality in every case is of insufficiency or total lack of implementation.

First of all, while an appropriate paint selection is fundamental to improving paintwork quality, paint is an organic material that deteriorates easily in sunlight, while some paints also weaken in high-humidity. For this reason, paint needs to be durability tested when selecting paint to the climate in Myanmar.

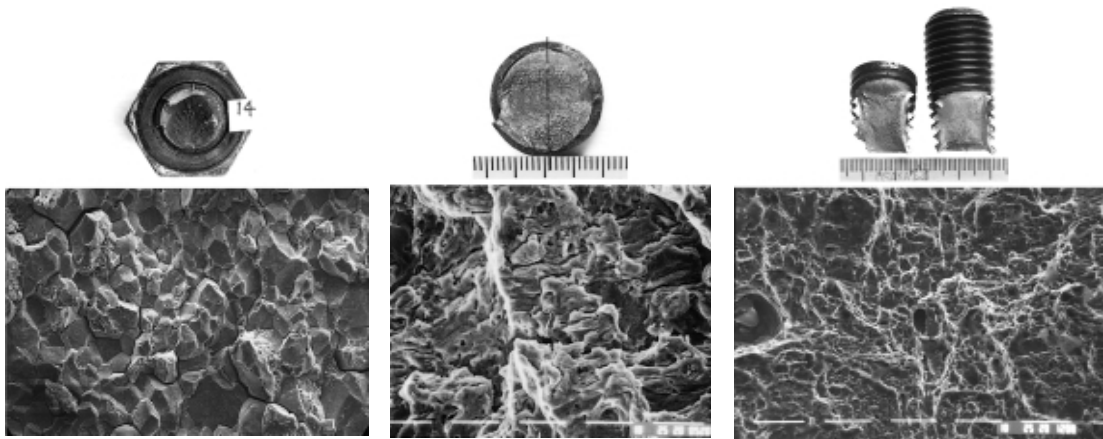
Similarly, appropriate quality control is essential because paintwork quality varies easily depending on the level of the work performed.

Furthermore, when maintaining paintwork, it is preferable that lifecycle costs are minimized through regular inspection and repainting before corrosion becomes severe.

The corrosion of suspension bridge cables also presents a serious issue. This time, while a detailed survey was not possible, it is thought anti-corrosion methods and cable protection methods must be totally improved.

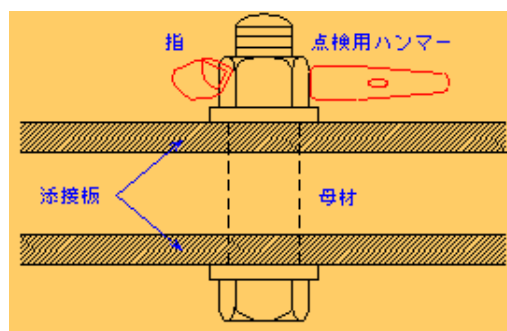
6) High-tension bolts

The damage to the high-tension bolts was found on the Pathein Bridge. It may have been resulted from delayed fracture which can cause sudden brittle fracture of bolts, even without the exertion of an external force on them and fatigue fracture by repeated loading and ductile fracture by excess loading. From inspecting the fractured surface of a bolt, it is possible to judge whether the damage resulted from delayed fracture or from fatigue fracture from repeated loading, or ductile fracture due to excess loading. Delayed fractures occur particularly easily the stronger the steel, and in case of high-tension bolts, it is known that occurrence is pronounced if the tensile strength of the steel exceeds 1,200N/mm². Due to this, it is recommended that the cause of the bolt fracture is inferred by examining the tensile strength and fractured surface of the bolt.



Photo—5.6 Types of fractured surfaces of bolts

Likewise, it is also recommended to prevent any fracture of high-tension bolts by using an inspection hammer. They are to check for abnormal tactile sensations with the fingers, sounds and vibrations in all the bolts manufactured in the same batch as the damaged bolt, or all bolts in the same section of the joint (splice plate) as the damaged bolt.



点検用ハンマーによるたたき点検

Figure—5.9 Inspection method

7) Other issues

Bridge piers that use cast-in-place piles raised up to water level such as are frequently used in Myanmar are by no means unproblematic in terms of how these piles are used. As regards design, however, they are being analyzed for elasticity as projecting piles, and apparently studies are also under way into horizontal force caused by collisions with ships.

Regarding scour, specific cases from the past need to be verified, and the acquisition of basic knowledge is required (not even maps were readily available when performing the site survey of bridges damaged by scour).

Regarding the alkali-silica reaction of the aggregate, though it was said that the concrete damage in Rakhine State was a contributory factor, no events were observed that particularly supported this. However, it's recommended to study on those matters through the contact with the persons in charge of the dam who have enough knowledge.

Appendix

Some new findings from the study [Research Study on Review and Application of the Bridge Engineering Training Center Project in Myanmar] by JICA, 2012

In Myanmar, 5 big bridges crossing Irrawaddy River have been constructed in these years and three of them were completed.

One of those bridges, Pakokku Bridge constructed in Middle Myanmar was opened for service on 31st Dec.2011.

This bridge is a road-rail bridge with 3,484m long main bridge and the steel weight of the superstructure truss is almost 30,000ton.

Even under the condition of not enough construction equipment and material, this bridge was completed only in two years including substructure work.

What kind of design and execution was done?

In the construction of the concrete slab of truss bridges, in case of the most popular Type III slab(P51), in some bridges, only bottom half concrete of the precast slab was placed on the ground and the upper half concrete was placed after it was carried on bridge trusses. This method might have been selected because of the lack of the capacity of the handling crane. But this method is extraordinarily out of the fundamental of the concrete placing. The durability of the bridge slab is deeply concerned.

On the background of this concrete slab fabrication, it may have been influenced by the Type IV(P52) bridge slab (as mentioned in P54-55, the design idea of this slab is out of the principle of reinforced concrete) used in Myanmar widely.

And in the approach concrete bridge, in any type of concrete bridges, reinforced concrete bridge (The main girder is prefabricated), pre-tension pre-stressed concrete bridge, post-tension pre-stressed concrete bridge, the connection of the precast concrete girder and cross beam seems extraordinarily simplified.

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