3.3.4 Results of bridge inspection

The results of visual inspection are shown here for each bridge. This section primarily describes major damages. For details, refer to the inspection recording forms, separately prepared for each span of bridges, in Appendix-4 Results of Bridge Inspection (visual inspection).

(1) Rama 4

Bridge type: PC box girder bridge
Bridge length: 278 m
Year of service start: 2006

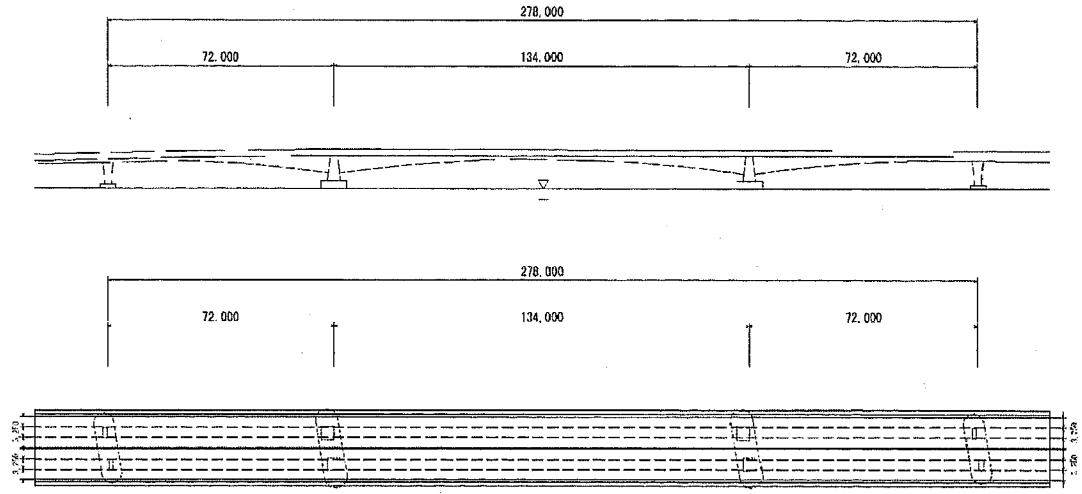


Figure 3.3.1: General drawing of Rama 4

Major damages include cracks on a side surface of the main girder near supporting point and free lime observed on the bottom surface of main box girder. (Fig3.3.2, Fig3.3.3)

Cracks on the side surface of main girder near supporting points are confirmed not only in the Rama 4 but also at multiple places of other PC box girder bridges having the same structure. In addition, although a comparatively small number of damages were detected in the main structure, many damages were found in attached facilities, e.g., inclination of poles for lighting facilities, lack of bolts in poles for hoisting national flags (probably, bolts were not installed from the beginning of construction).

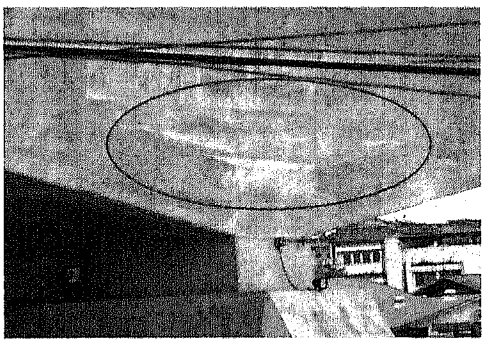


Figure 3.3.2: Cracks in Rama 4
(Web of main girder)

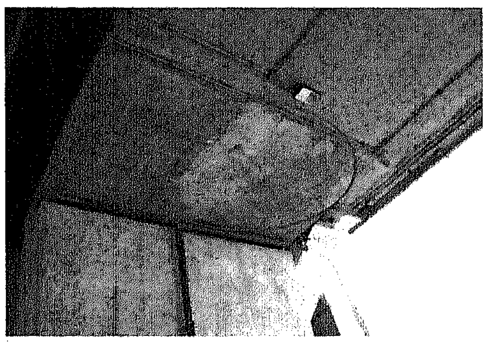


Figure 3.3.3: Free lime of Rama 4
(Lower Flange of girder)

(2) Rama 5

Bridge type: PC box girder bridge
Bridge length: 466m
Year of service start: 2002

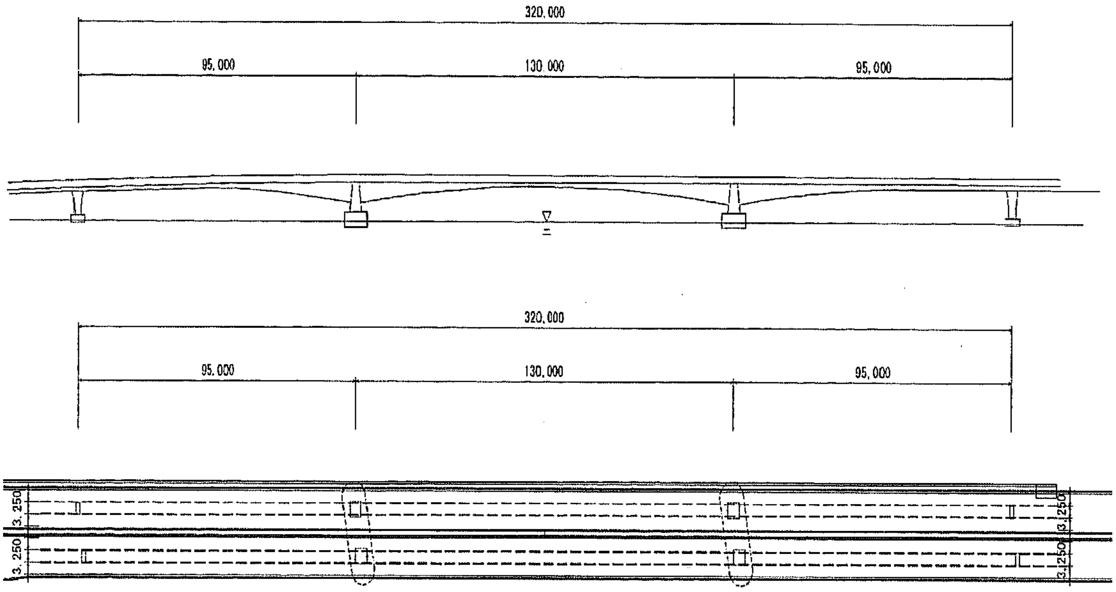


Figure 3.3.4: General drawing of Rama 5

Cracks and free lime were found on a web of the main girder and bottom surface of projected deck. (Fig 3.3.5, 3.3.6) Inclined columns, ground settlement around them, ejection of sand were found in the Thon Buri side. (Fig3.3.7, 3.3.8) Although inclined bridge columns may cause moving constraint of bearings, cracks and pop-outs were not found in the upper structure around bearings. The urgent needs for repair may not be needed, however, in-depth survey was recommended for searching the causes of that phenomenon. In response to a report submitted to the DRR from a viewpoint of the necessity of more detailed inspection of these damages, investigation for determining the cause, and monitoring the movements, the DRR made a prompt notification of its intension to start monitoring.

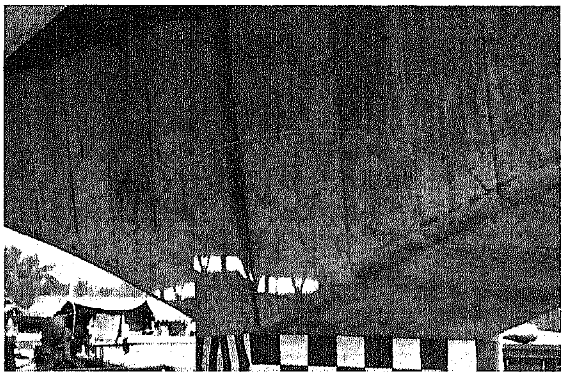


*Figure 3.3.5: Cracks in Rama 5
(Web of main girder)*

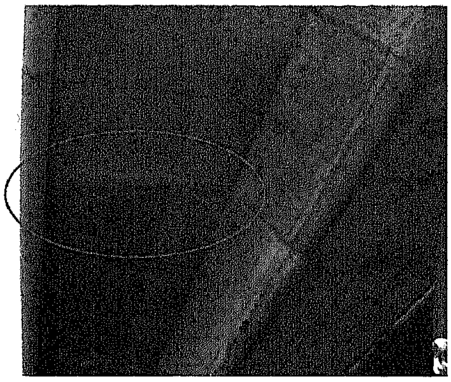


*Figure 3.3.6: Cracks and free lime in Rama 5
(Bottom surface of projected deck)*

*Figure 3.3.7: Inclination of bridge columns of
Rama 5 (Thon Buri side)*

*Figure 3.3.8: Ground settlement around Rama 5
(Thon Buri side)*

(3) Rama 7

Bridge type: PC box girder bridge
Bridge length: 290m
Year of service start: 1992

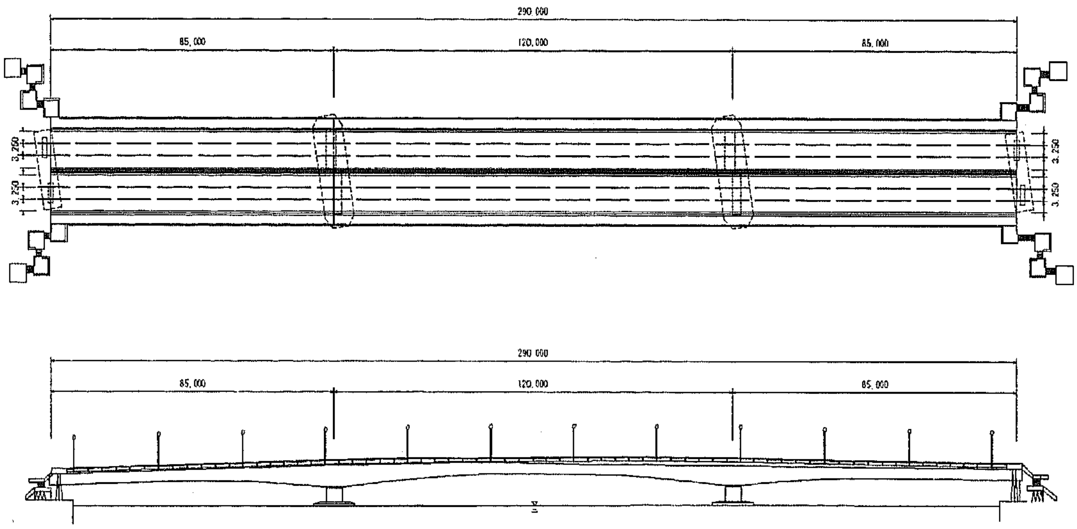


Figure 3.3.9: General drawing of Rama 7

Similar to other PC box girder bridges, cracks were found on a web of the main girder around supporting points. (Fig3.3.10, 3.3.11) These cracks had marks of repair in the past. Free lime on bottom surface of a deck and pop-outs at ends of beams were detected. Although the possibility of moving constraint of a bearing was found, no cracks were observed in the shoe seat motor or an abutment near the relevant bearing.

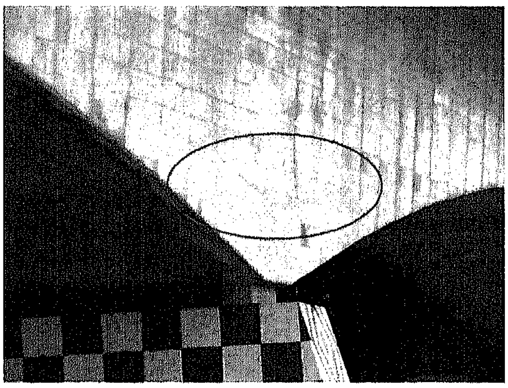


Figure 3.3.10: Cracks in Rama 7
(Web of main girder)

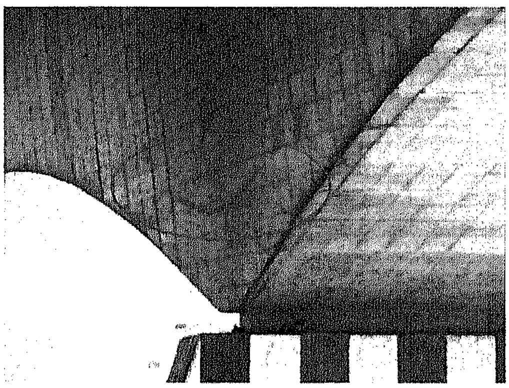


Figure 3.3.11: Cracks in Rama 7
(Web of main girder)

(4) Phra Pinklao

Bridge type: PC box girder bridge
Bridge length: 280m
Year of service start: 1973

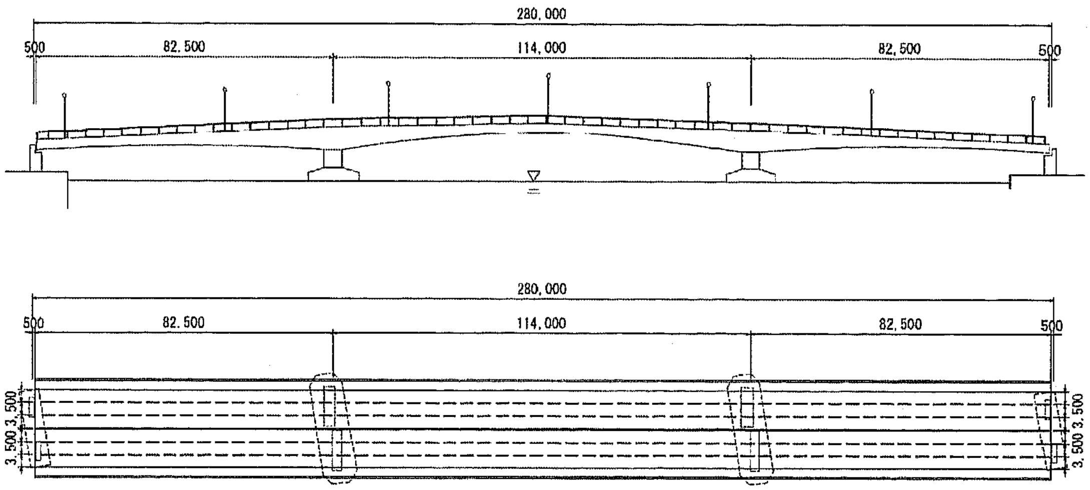


Figure 3.3.12: General drawing of Phra Pinklao

Cracks and free lime were found on a web and lower flange of main girder. (Fig3.3.13,3.3.14)

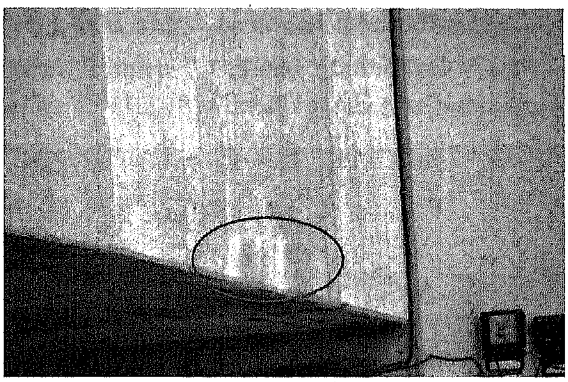


Figure 3.3.13: Phra Pinklao
(Cracks and free lime on girder)

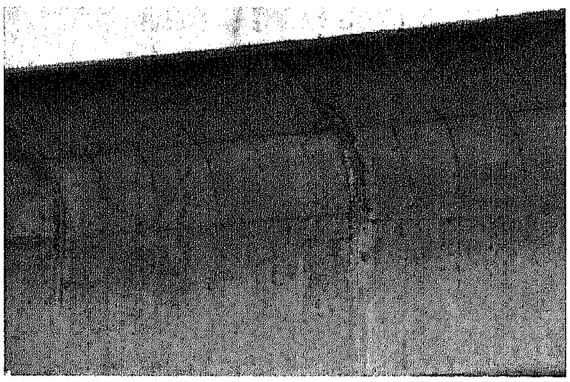


Figure 3.3.14: Phra Pinklao
(Cracks and free lime on girder)

(5) Phra Pokklao

Bridge type: PC box girder bridge
Bridge length: 212m
Year of service start: 1984

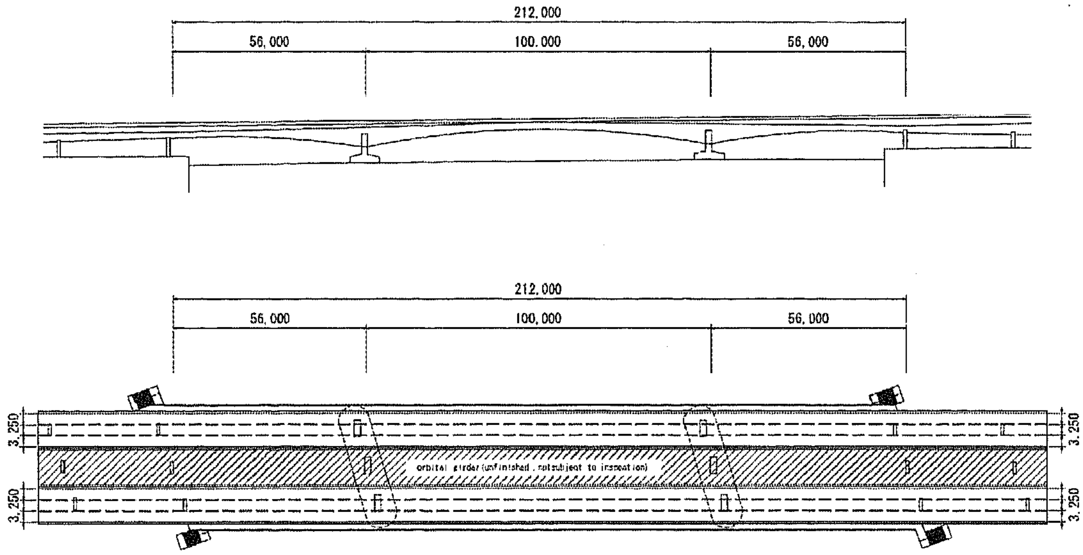


Figure 3.3.15: General drawing of the Phra Pokklao

Similar to other PC box girder bridges, cracks were observed on a side surface of the main beam near supporting points. (Fig3.3.16, 3.3.17) In addition, marks of contact with ship (collision), pop-outs of handrail, and cracks were observed.

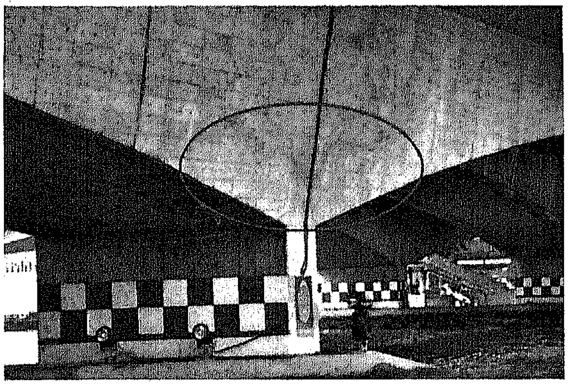


Figure 3.3.16: Cracks in the Phra Pokklao (Web of main girder)

Figure 3.3.17: Cracks in the Phra Pokklao (Web of main girder)

(6) Taksin

Bridge type: PC box girder bridge
Bridge length: 224m
Year of service start: 1982

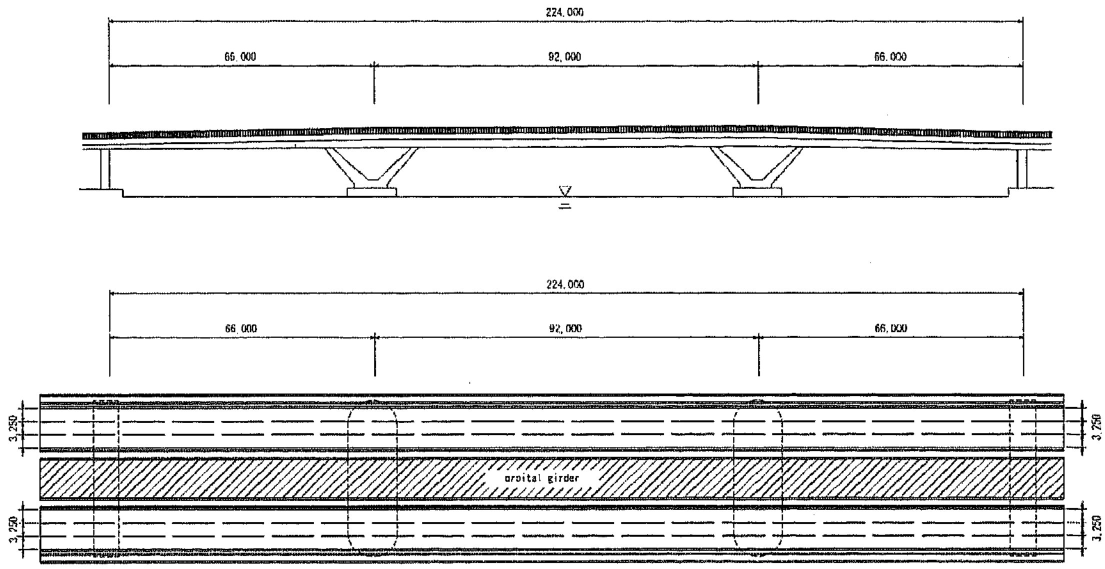


Figure 3.3.18: General drawing of the Taksin

Cracks in the diagonal direction were found on a web of the main girder. In addition, cracks were found around the corner of intersection in bridge main girders and on a web of bridge columns. (Fig3.3.18) Cracks together with free lime and the possibility of moving constraint of bearings were confirmed.(Fig3.3.20)

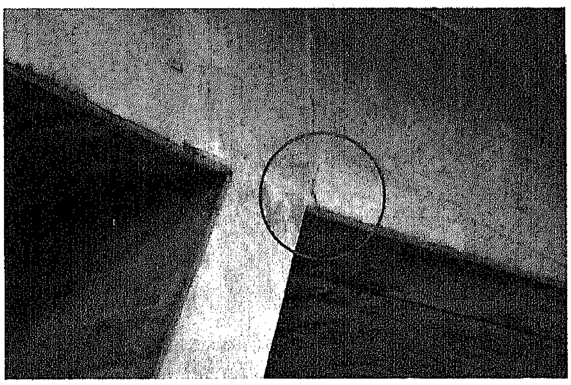


Figure 3.3.18: Cracks in the Taksin (Web of main girder)

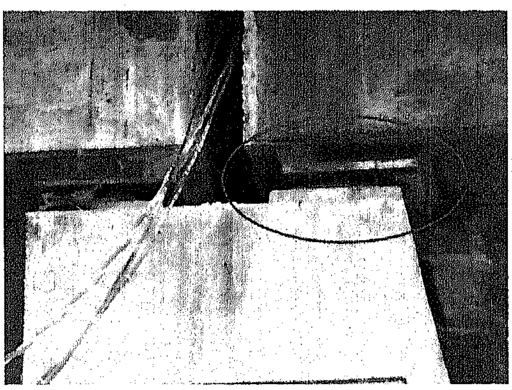


Figure 3.3.20: Moving constraint of bearings in the Taksin

(7) Rama 3

Bridge type: PC box girder bridge
Bridge length: 476m
Year of service start: 2000

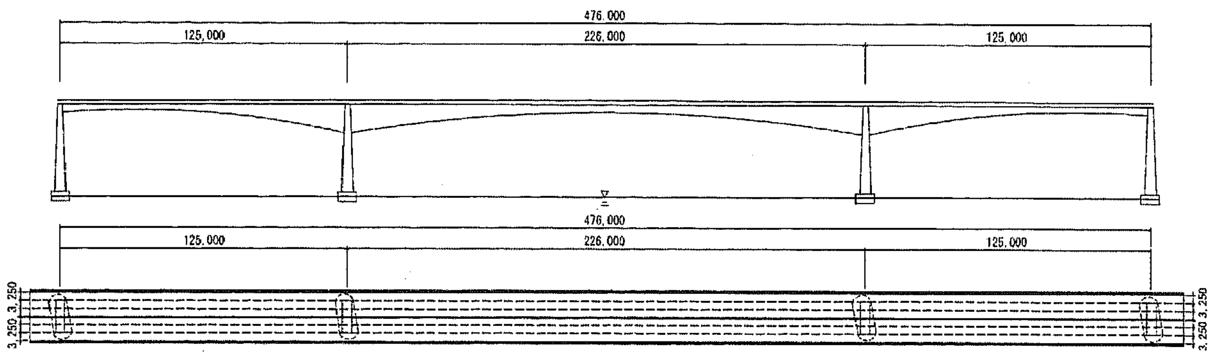


Figure 3.3.21: General drawing of Rama 3

Cracks were found on the bottom of a web and bottom surface of projected area of a deck. (Fig3.3.21) Cracks with free lime in part were also found.(Fig3.3.23)

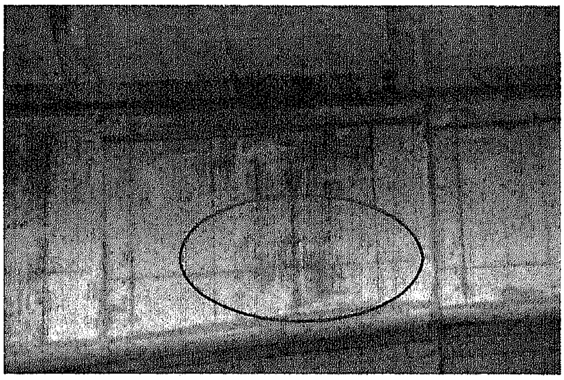


Figure 3.3.21: Cracks in Rama 3 (Web of main girder)

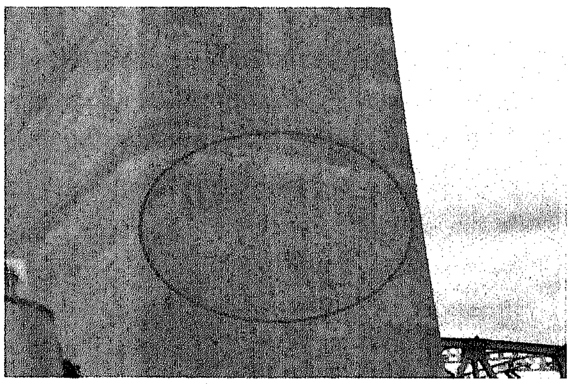


Figure 3.3.23: Cracks in Rama 3 (Web of bridge columun)

(8) Krung Thon

Bridge type: Steel truss bridge
Bridge length: 366m
Year of service start: 1958

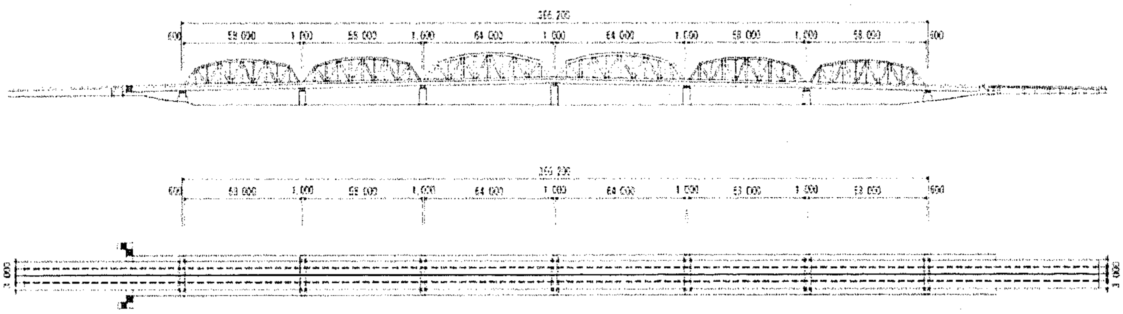


Figure 3.3.4: General drawing of the Krung Thon

Deformation was observed in many members, lower chords, lower lateral bracings. (Fig3.3.25,3.3.26) They were caused by the collision with ships passing under the bridge. In addition, deformation was observed in some places at the top of vertical members of the bridge.

As other damages, cracks and pop-outs are observed in protection concrete around the bottom of diagonal members on the bridge deck. Cracks on a deck, free lime, cracks in concrete under bearing were observed.

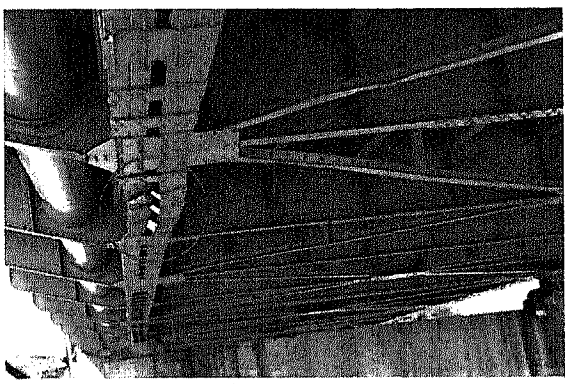


Figure 3.3.25: Deformation of the Krung Thon (Lower chord, Lower lateral bracing)

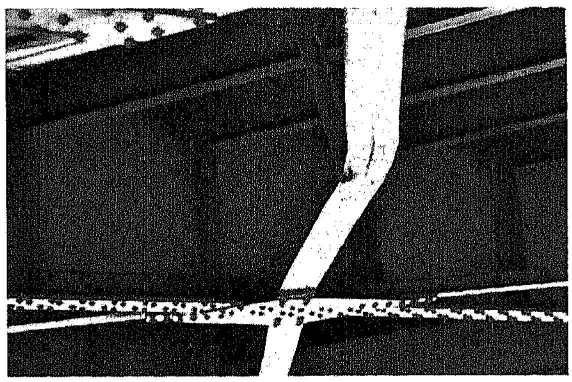


Figure 3.3.26: Deformation of the Krung Thon (Lower lateral bracing)

(9) Memorial

Bridge type: Steel truss bridge
Bridge length: 227.918m
Year of service start: 1932

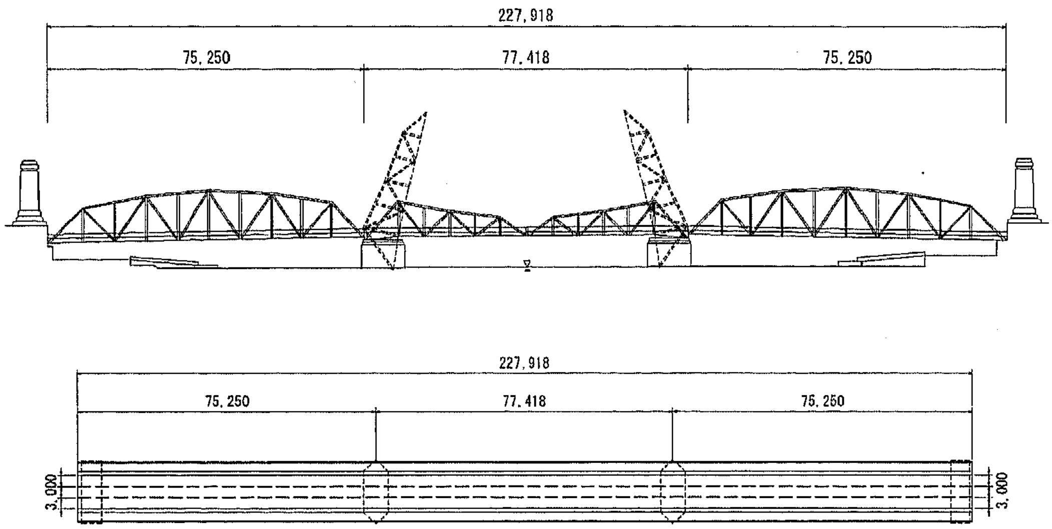


Figure 3.3.18: General drawing of the Memorial

Similar to the Krung Thon, lower chords, lower lateral bracings were observed deformed. They are also considered to be caused due to collision with ships/ vehicles passing under the bridge.(Fig3.3.28, 3.3.29)

In addition to corrosion and cracks of protection concrete at the bottom of diagonal, free lime and marks of water leakage from the place where diagonal passes through a deck on the bridge face were observed. In particular, free lime and marks of water leakage from the deck pass-through area confirmed entry of rain, and water that has entered the deck may pond depending on the configurations of the diagonals pass-through decks.

Corrosion was observed on a splice plate at the center span. The configuration allows rain to pond easily in this area, and corrosion wastage was observed in some portions. In the current state, corrosion areas were painted. It might be quick fixes.

Missing and loosened bolts were observed at a splice plate. Bird droppings were also observed.

Other observed damages of concrete members included cracks, free lime in a deck, and cracks in columns.

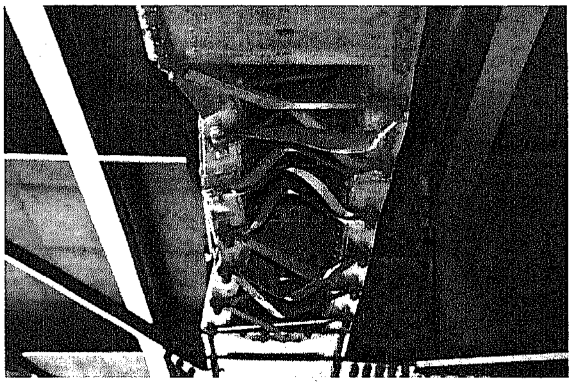


Figure 3.3.28: Deformation of the Memorial (lower chord)

Figure 3.3.29: Free lime of the Memorial Mark of water leakage (Deck pass-through area)

(10) Krung Thep

Bridge type: Steel truss bridge
Bridge length: 354m
Year of service start: 1959

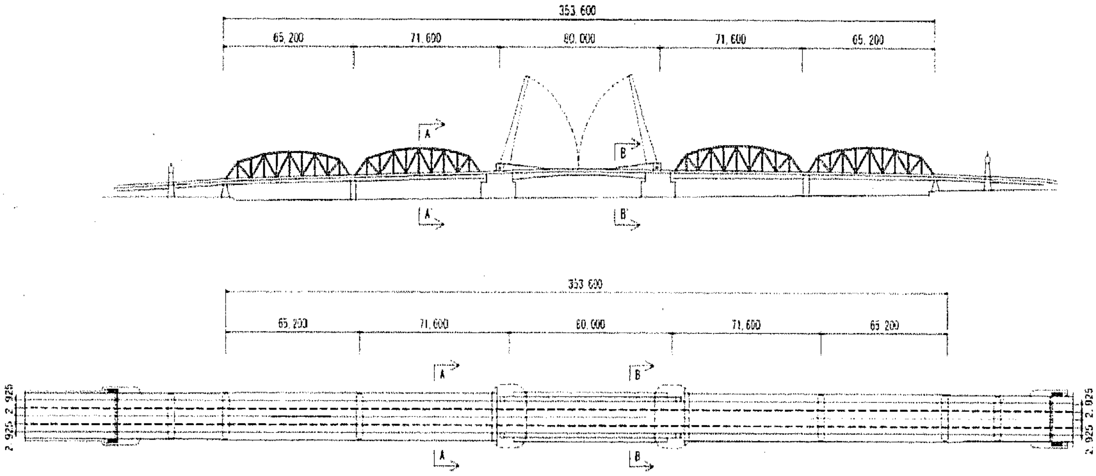


Figure 3.3.30: General drawing of the Krung Thep

Inspectors on a ship found cracks propagated on the steel plate at the bottom surface of the deck in the bascule leaf (Thon Buri side). Road surface at the center joint of the leaves seemed to be a gap approximately 30 mm. Other observed damages included cracks and free lime in an RC deck.

The number of deformed portions in lower chords and lower lateral bracings was smaller than those found in the other truss bridges (Krung Thon and Memorial). In the deck pass-through area at the bottom of diagonal, water proofing with sealing had been taken between concrete and diagonal to avoid rain entry. However, deterioration was observed in those sealing materials.

Pop-outs were observed on the bottom surface of the deck where diagonal passed through. (Fig3.3.32)

Decrease of thickness of cross section (corrosion wastage) due to corrosion was observed at the bottom surface of vertical stiffener in the center span. It may be a place where rain ponds easily.

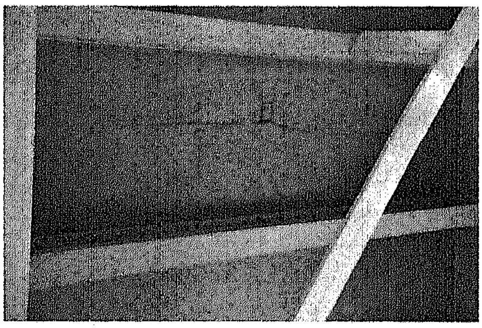


Figure 3.3.31 Krung Thep Crack (steel place at the bottom surface of a deck)

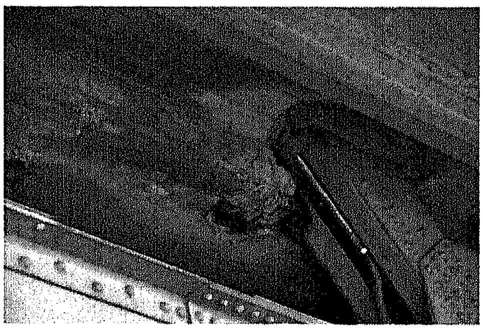


Figure 3.3.32: Pop-outs in the Krung Thep (Deck)

(11) IRR South

Bridge type: Cable stayed bridge
Bridge length: 702m
Year of service start: 2006

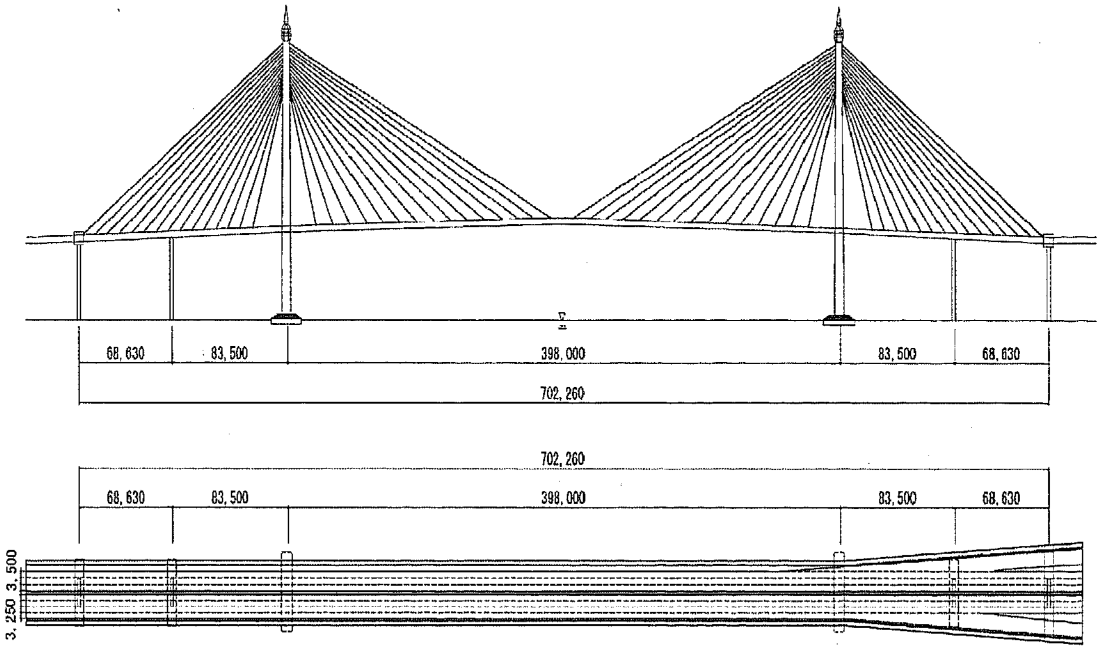


Figure 3.3.33: General drawing of the IRR South

Cracks in horizontal and vertical directions were found in a main tower. Cracks were also found to propagate downward from a corner of intersection near the rigid joint between the main tower and the cap beam. In addition, corrosion was observed in a door for maintenance activities on the main tower.

Several cracks on a cap beam (web surface) joined with the main tower were visually confirmed from the surface of the bridge. Also, several cracks propagated near a cable fixing area on a projected deck were found.

Cracks were also found around the cable fixing area on the main tower, and oil leaked from a cable damper. (Fig3.3.34,3.3.35)

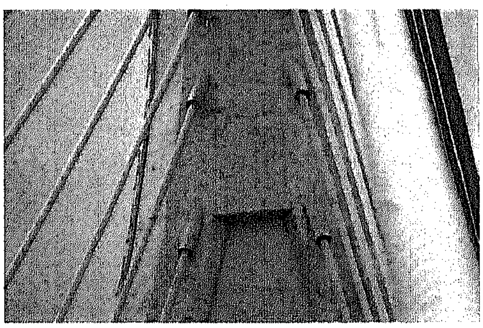


Figure 3.3.34: IRR South
(Cracks around a cable fixing area)

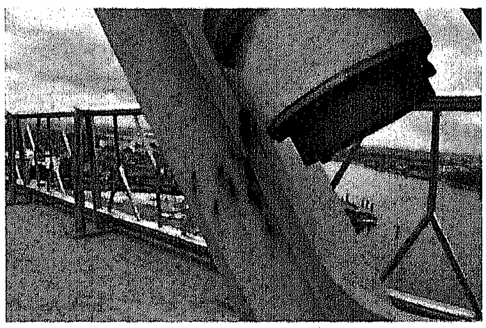


Figure 3.3.35: IRR South
(Oil leakage)

(12) IRR North

Bridge type: Cable stayed bridge
Bridge length: 576m
Year of service start: 2006

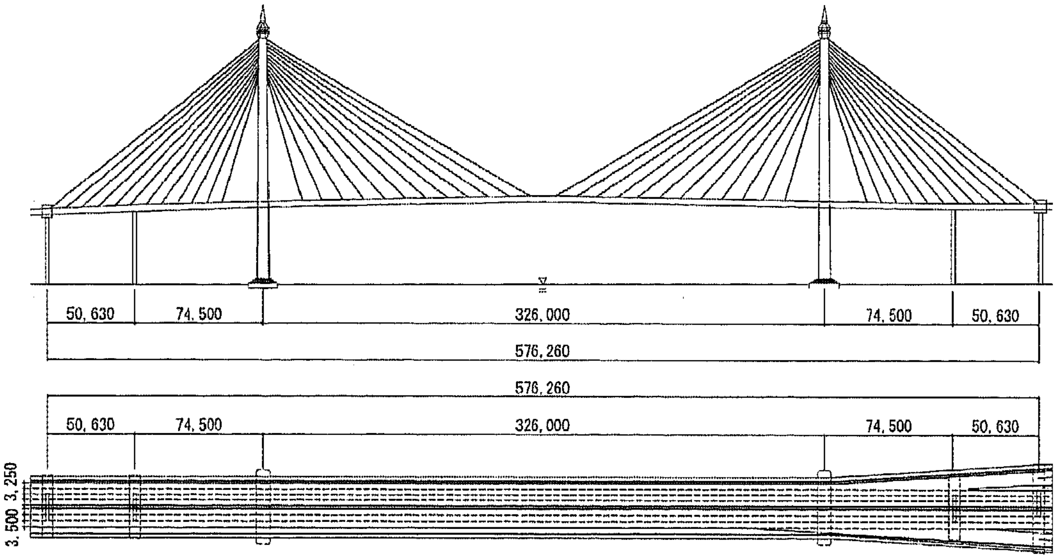


Figure 3.3.36: General drawing of the IRR North

Cracks were in the vertical direction on the lower side of main tower, and reticulated cracks were found at the end bridge column. Cracks were also visually confirmed from the acute angle corner at the rigid joint connected the cap beam with the tower.

Cracks of cap beam and precipitation of free lime were confirmed in the V-shape bridge column. In the end bridge column, streaks were visually confirmed at equal intervals in the horizontal and vertical directions, and reticulated cracks were also found on them.

In the projected decks (concrete slab), multiple cracks were found in the same direction. (Fig 3.3.38)

Precipitation of free lime was also detected near the base of fittings of pipes.

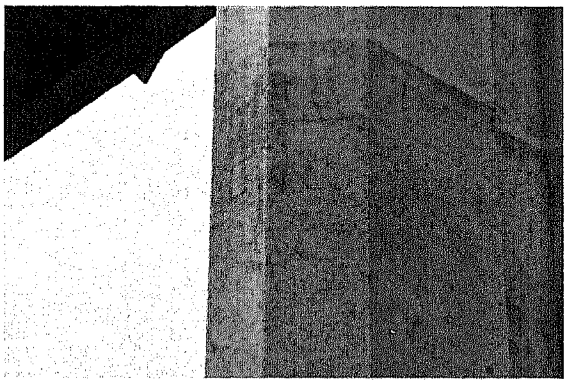


Figure 3.3.37: Cracks in the main tower of the IRR North

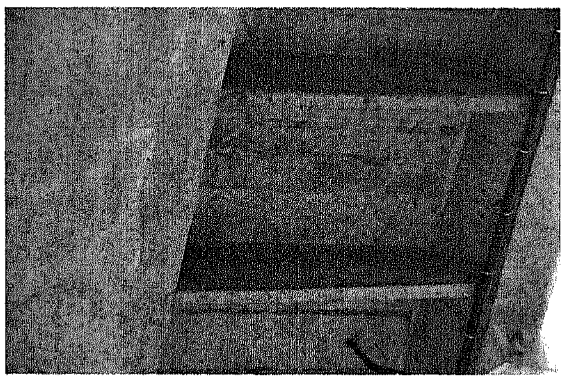


Figure 3.3.38: Cracks of a deck of the IRR North

3.3.5 Summary

The results of visual inspection of bridges over the Chao Phraya river are described below.

1) PC bridges

Damages were few in whole, and same damages were apparently repaired. Like Rama 5, however, inclination was found in bridge columns. The details would be appeared in 3.5.2.

2) Steel truss bridges

Considering the in-service period, the maintenance was fully implemented. However, procedures are considered to be necessary to detect crack propagation in composite decks of Krung Thep at an early stage. If cracks are detected during repainting work and reported them to DRR, DRR officers can make a decision to do next steps before the damage becomes more serious. Lower chords and lower lateral bracing were deformed and some lateral bracing were missing due to collision with ships and/or vehicles passing through those bridges. Including those, further discussions are appeared in 3.5.1(2).

3) Cable stayed bridges

Various cracks and free lime were found in the main tower, cap beams, or projected deck or end bridge columns. Further discussions are appeared in 3.5.1(3).

3.4 Collection of additional data and survey for evaluation

3.4.1 Investigation of inland transportation by water

From the site reconnaissance, collision on bridges with inland transportation has to be considered for keeping those bridges in good conditions. Regulations on shipping routes and present movement of boats were investigated to make a proposal for safety assurance.

(1) Regulations

The research results of for laws related to regulations of shipping routes are as shown below.

- The Thai Vessels Act impose ship owners to resister their ships in a appropriate manner.
- Large international ships are permitted to navigate to the Krung Thep constructed 45 km away from the mouth of the river.
- Only registered carrying vessels can navigate the upstream from the Krung Thep.
- Carrying vessels (40 to 50 m long and 3 to 5 m high) cannot drive themselves.
- The space for passage of ship is 60 m wide and 5.5 m high at the bridges, which information was received form the member of Bureau of Road Maintenance,

(2) Present situations of ships passing

The following results of confirmation were obtained by asking DDR Road Maintenance Bureau.

Heights of ships themselves are not restricted. Carrying Vessels are usually equipped with a device for pouring water into a certain parts in the vessel to lower the vessel height when they are under no load. However, it is observed that some vessels do not use this device. This is assumed to be a factor of contact with bridge.

Since some ships without names navigate, ships that have contacted beams may not be specified even by recording their photos. If such ships are specified, some of them suffer economic hardships and cannot pay expenses necessary for repair the damages. In this case, the cost for repair may be spent by DRR.

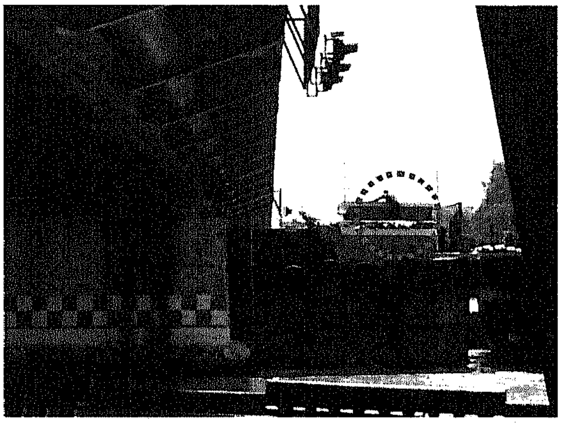
The water police do not so positively catch such criminals who had accidents by making their ships contact bridge elements.

On the other hand, the results of site reconnaissance distinctively indicate contact of ships with lower chord and lower lateral bracings in the three steel truss bridges (Krung Thep, Memorial, and Krung Thon).For details, refer to 3.3.4 "Results of bridge inspection" and Appendix 4.

In the field (Krung Thon), carrying vessels towed by a tugboat passed through under the bridge was observed. In the both picture of Figure 3.4.1 and 3.4.2, the upper stream is at the left and the downstream is at the right. The photo was taken near Thon Buri said. (Bangkok is at the further in this picture). Figure 3.4.1 shows that a sailor checks the space by his eyes whether the vessel can be passed. Figure 3.4.2 shows the space between the vessel and lower lateral chord can be seen 50 cm at most.

Once a tugboat begins towing such the vessels, they cannot actually stop before the bridge, although water flow decelerates them. If visual check is adopted for confirming the space, it will not be able to avoid collision with bridges.

From this observation in the field, it may reveal low awareness of people related to space between ships and bridges.



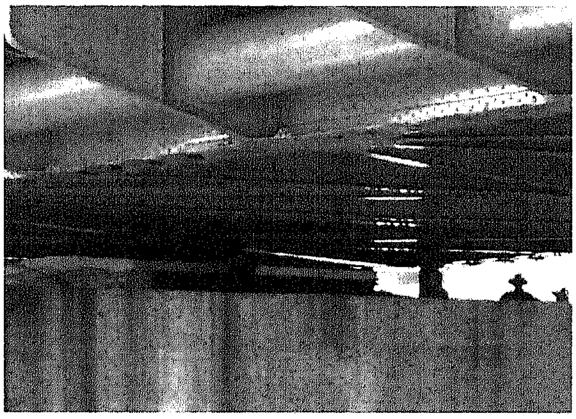


Figure 3.4.1: Condition of passage of a vessel (1) Figure 3.4.2: Condition of passage of a vessel (2)

(3) Proposal for safety assurance

A system used in Japan for warning ships approaching gates. This system was introduced to the DRR. This system can identify ships and waves of water, specify ships' bodies and its speed. If collision or contact may occur, the system gives an alert by light and sound.

On the other hand, the DRR is making a plan to spend budget for this fiscal year to install a system at Phra Pinklao, which generates warning beep, takes a picture of ship' body. In addition, this system can record this information in CD automatically.

Considering the present situations previous mentioned in 3.4.1(2), installation such device is under the necessity of warning ships.

For the reasons above, a realistic way for preventing ships from contacting bridges is to implement the device which is currently planed by the DRR.

3.4.2 Traffic volume by vehicle type

Traffic volume by vehicle type was surveyed for analyzing bridge inspection results. Especially heavyweight trucks can be the cause of fatigue damages in steel structures. Targeted bridges, Krung Thon and Memorial, were selected based on the results of hearing at DRR. This survey was carried out 2 days. (one day in weekdays and the other day in holidays (for 24 hours)).

Reasons for selecting Krung Thon and survey period were as follows:

- The bridge is located in a primary transportation route of cargos from prefectures in the west parts of Bangkok to the city of Bangkok. So heavyweight vehicles can be easily recorded in the route. (Those are the cause of fatigue problems on the steel structures.)
- A weekday and a holiday were set, because types and the number of vehicles passing are generally different between weekday and holiday.

The traffic volume survey by vehicle type at Memorial was carried out in contrast to the results of Krung Thon.

It is regulated that, for load limit values, vehicles of up to 21 tons can pass through Krung Thon and vehicles with up to 6 wheels can pass through Memorial. However, trucks cannot pass through the bridges between 6:00 and 10:00 and between 15:00 and 21:00, excepting public holidays.

The results of traffic volume survey are detailed in Appendix-12. Here is described the number of vehicles whose load value exceeds the load restriction. (Table 3.4.1)

- Krung Thon

Table 3.4.1 Number of violator vehicles (Krung Thon)

	Holiday		Working day	
Types of vehicles	To Bangkok	To Thon Buri	To Bangkok	To Thon Buri
Medium Truck(6wheels)	0	0	210	160
Truck (10wheels:25ton)	135	153	125	102
Semi-Trailers(18-22wheels:40-50.5ton)	76	93	80	115
Trailers ((18-22wheels:47-53ton)	83	87	82	73
TOTAL	23752	33468	32927	35080

- Memorial

According to the inspection between 0:00 Tuesday November 30 and 24:00, the number of vehicles which was 1 (total number of vehicles passing through: 39286, in 24 hours).The type of the violator vehicle was a truck (10 wheels: 25 tons).

(4) Conclusion and consideration

Of 68007 vehicles, in total, passing through Krung Thon on a weekday, 947vehicles (13%) were violators vehicles.

Of 57220 vehicles, in total, passing through on a public holiday, 627 vehicles (1.1%) were violators vehicles. In Memorial, load restriction was comparatively observed.

The number of trucks, semi-trailers and trailers passing through the bridge, each of which is equipped with 2 axes and 8 wheels in its rear portion, becomes a problem in particular on the fatigue endurance of steel structures. The fatigue endurance of steel structures is reviewed in 3.5.1 Superstructure work by using the results shown here.

3.4.3 Inspection of river-bed scour status

For Krung Thon and Krung Thep, river-bed scour was inspected. The DRR is assumed to have conducted periodic inspection to take measures against river-bed scour by sinking gabions, if necessary. (See Table2.2.6) However, since detailed reference materials for the measures were not received, this section describes whether changes have been made in comparison with the results of river bed- scour inspection carried out in 1982.

(1) Method of inspection

For the measuring instrument, fishfinder (GARMIN's Fishfinder 400C) was used. However, since echo emitted from the boat to footings may reflect, accurate measurements around footings was seemed to be difficult, So values must be checked before compared in advance with those obtained by a method using weight, and the difference in each value was confirmed within 50 cm.

(2) Results of inspection

For both Krung Thon and Krung Thep, each value compared with the results of the inspection in 1982 was approximately within the range of ±2 m.

3.4.4 Geological layer around Bangkok and record of seismic observation

(1) Geological layer condition

- The geological layer around Bangkok is classified as that of Quartermary Era, Holocene epoch. Accumulations are those of the alluvial formation (sand gravel, sand, silt, clay, sea sand and mud).
- The surface layer of Bangkok city is a weak geological layer. The thickness is seemed to be approximately 15 m in the north of the city and about 20 m near the seashore,
- Judging from the results of boring between Bangkok's downtown and the bay, the layer of up to 20 m from the land surface is thought very weak..

(2) Seismic observation records

- In Thailand, dislocations exist in the Malay Peninsula, near the Myanmar border, in the northwestern area (Chiang Mai, Chiang Rai), and near the Laos border. In the western area of Thailand, the dislocation is moving toward the Indian Ocean.
- Noticeable earthquakes observed in Bangkok have been recorded 14 times for 10 years from 2001 to 2010. Of them, 13 earthquakes were perceived in high buildings. On the contrary, they were not perceived in medium- and low-rise buildings.
- Earthquake movement at high buildings was recorded 4 times in 2007 and 2008.
- These recorded earthquakes occurred in Sumatra, Myanmar, China, Laos, etc..