MINISTRY OF TRANSPORT
ARAB REPUBLIC OF EGYPT

FOLLOW-UP COOPERATION STUDY ON THE BRIDGE DESIGN (COUNTERPART TRAINING FOR THE SUEZ CANAL BRIDGE PROJECT)

FINAL REPORT

OCTORBER 2016

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
CHODAI CO., LTD.

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Contents

Page

CHAPTER 1 INTRODUCTION

1.1 Objectives of the Study

1.1.1 Background of the Study

The Suez Canal Bridge was constructed by the Grant Aid of Japan. After it was handed over in September 2001, the bridge was opened in October 2001 as a toll road. Upon the construction, the counterpart trainings were implemented because the Authority for Roads, Bridges and Land Transport (hereinafter GARBLT) doesn't have enough experience of long-span bridges. This follow-up cooperation study (hereinafter called F/U) will follow "The Bridge Design Counterpart Training (Counterpart Training for the Project for Construction of Suez Canal Bridge)".

After the ferry service was stopped, cracks were found on the bridge surface along the westbound lane. Despite the vehicle axle load limitations and further proper maintenance, cracks on the surface of the Suez Bridge have progressed considerably. After the investigation JICA recommend the repairing method (March 2013). Following the JICA' recommendation GARBLT contracted with consultant and contractor. But due to the political instability, the army closed the Suez Canal Bridge and the repairing works have been stopped.

Under these circumstances, GARBLT has informed JICA that the repairing works will be started after the decision of the repairing method and the steel deck will be checked after the removal of pavement. GARBLT recognized that the necessity of the advices by specialists about the evaluation of the damage to the Steel Deck plate, the selection of effective repairing method, so that GARBLT requested this follow-up cooperation study.

1.1.2 Objectives of the Study

The thickness reduction due to the corrosion may not be a big problem at the moment, but can be a serious problem in future. GARBLT will execute the experimental on-site pavement, the pavement of the bridge deck, and the soundness investigation of the Steel Deck plate. The study team will guide and advise the items below

- The evaluation of the on-site trial pavement and the main pavement of the bridge deck.
- The soundness investigation and the evaluation for safety of the Steel Deck plate
- The execution plan for Repairing works and the maintenance management plan of the Steel Deck plate

1.2 Summary of the past Surveys

1.2.1 Structure of Pavement

Pavement detail structure of the Suez Cannel Bridge is as follows:

- Waterproof adhesive layer (three layers in total): After removing temporary paint on the surface of the steel deck using sandblasting, two layers of waterproof anticorrosion and an adhesive layer are applied.
- Asphalt base course (SMA 40 mm, improved type II, reinforced by plant fiber)
- Adhesive layer (after surface cleaning of base course, a tack coat is sprayed.)
- Asphalt surface (40 mm, improved type II)

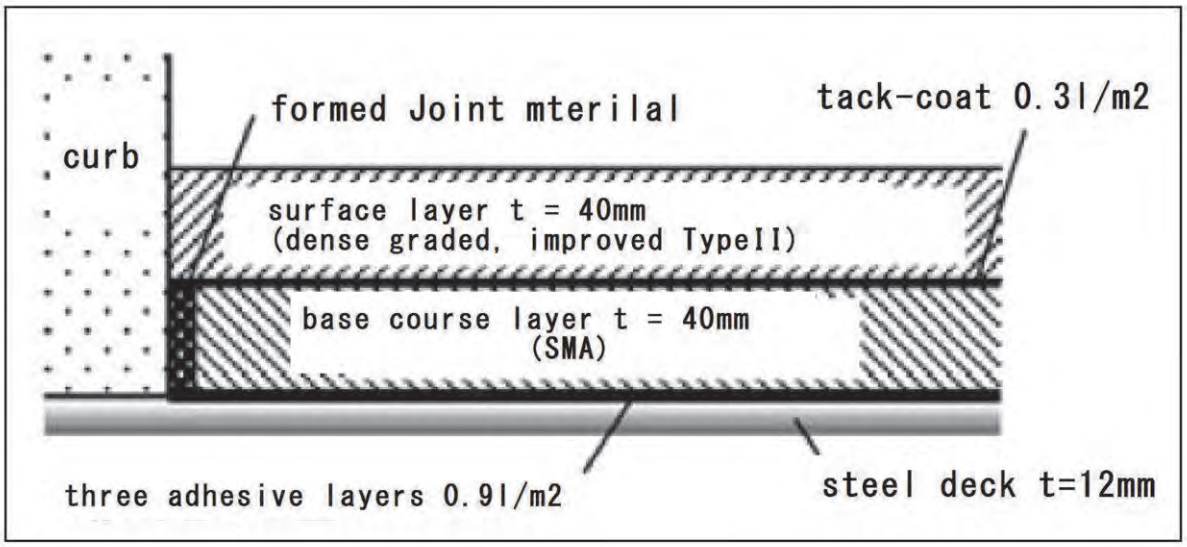


Figure 1.2.1 Pavement Structure Diagram

1.2.2 Result of Survey in May 2011

The Survey Team conducted an investigation of damaged pavement conditions in May 2011. The honey-comb shaped cracks with a maximum width of 30 mm and depth of 50 mm, were identified and the fragmentation of the pavement surface was confirmed. Although cracks were expected to reach the base course, cracks that reached the steel deck beyond the base course were not identified.

1.2.3 Result of Survey in August 2011

The Survey Team conducted an investigation on damage conditions of the pavement in August 2011. The area and the width of cracks had increased since the survey in May 2011. In addition, the progress of damage to the pavement, such as the occurrence of potholes and the crack width and depth increases were confirmed.

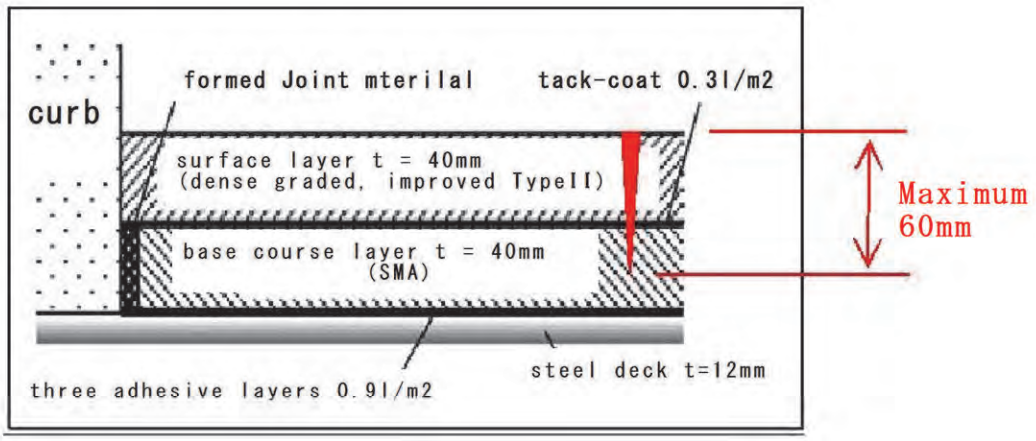


Figure 1.2.2 Cracks Survey (Maximum crack depth 60 mm was confirmed)

1.2.4 Result of Survey for Steel Deck in May 2011

The Survey Team conducted an investigation of damage conditions of the steel deck in May 2011. Pictures were taken with an infrared camera at a position inside the steel box girder and no severe damages were found.

1.2.5 Result of Survey in 2011 & 2012

(1) The damage of surface of pavement

Overall damage conditions on the entire area of pavement on the surface of the Bridge were inspected. As a result of the inspection, the following information was revealed:

The cracks appeared in 95% of the pavement area.

Approximately 70% of the area had some cracks with a width of more than 10 mm.

In particular, the cracks in the driving lane (outer lane) in the south section was most evident.

In order to confirm the detailed condition of cracks, evident six damaged locations were selected and drilled to remove the pavement of 6 m length × 4 m width for each location. The maximum crack width was 40 mm, and cracks of more than 10 mm width penetrated the base course layer. Where the maximum crack width was 40 mm, the asphalt pavement was partially separated from

the base course layer, and the bonding layer between the steel deck plate and the base course layer was deteriorated.

The core sampling test (100 mm diameter) of six damaged locations revealed that that cracks completely penetrated the pavement and the bonding layer was not functioning properly. It was determined that the cracks were caused by passage of overloaded vehicles under uncontrolled axle load limitations soon after the bridge inauguration. The crack width and depth developed further due to insufficient repair measures by GARBLT. Moreover, rainwater penetrated these cracks and the waterproof performance in the bonding layer was lost. This deterioration resulted in more crack development.

(2) The damage of Steel Deck plate

In order to investigate the existence of damage to the steel members of the steel deck, a surface inspection (visual inspection and measuring the thickness of the steel deck plate by ultrasonic method) and an inspection from inside of the box girder (visual inspection and the inspection of fatigue cracks on the connected parts of U-shaped ribs by ultrasonic method) have been carried out.

After selecting two healthy places (0.3 m length × 0.3 m width) and three places having significant damages (1 m length × 1m width), a surface inspection of the steel deck was conducted by visual inspection and ultrasonic investigation.

By visual inspection, some water was found entering the lower side of the bonding layer and rust was found on the surface of the steel deck plate in all inspected areas.

The thickness of the steel deck plate reduced by rust was measured by ultrasonic method after carefully removing pitted corrosion attached to the upper surface.

The thickness reduction was different depending on the investigated positions. The corrosion found on the driving lane of south section had progressed considerably compared to the north section. Steel plate thickness reduction by corrosion was less than 1 mm and most parts were about 0.5 mm.

Reduction of thickness due to corrosion may not be a big problem at the moment in terms of structure. However, if no measures are taken, fatigue cracks may occur from the top deck plate and threaten the structural soundness. To confirm the structural safety of the Bridge, the stress of the longitudinal ribs of the steel deck plate was calculated and analysed for the case where the thickness of the steel deck plate was reduced to 11.5 mm or 10.0 mm from the original thickness of 12.0 mm. As a result of the analysis, even if the plate thickness becomes 11.0 mm, the stress changes are small and less than 1%. Therefore, it was concluded that there is sufficient margin for the allowable stress.

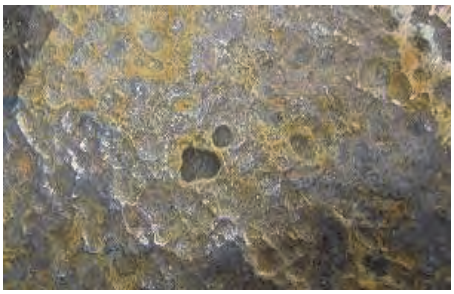
In addition, the damage existing in the internal structure of the steel box girder was investigated. Ultrasonic method was used to try to detect cracks. However, no fatigue cracks were found.

The results of the external and internal investigation of the steel deck plate showed no fatigue cracks, but rust on the surface of the steel deck and deterioration of the bonding layer was confirmed. This should be a result of the progression of damage on the pavement and cracks reaching the surface of the steel deck.

In conclusion, it is indispensable to repair the existing pavement and the bonding layer on the entire surface of the steel deck plate using appropriate repair methods after removing the rust on the surface of the steel deck.

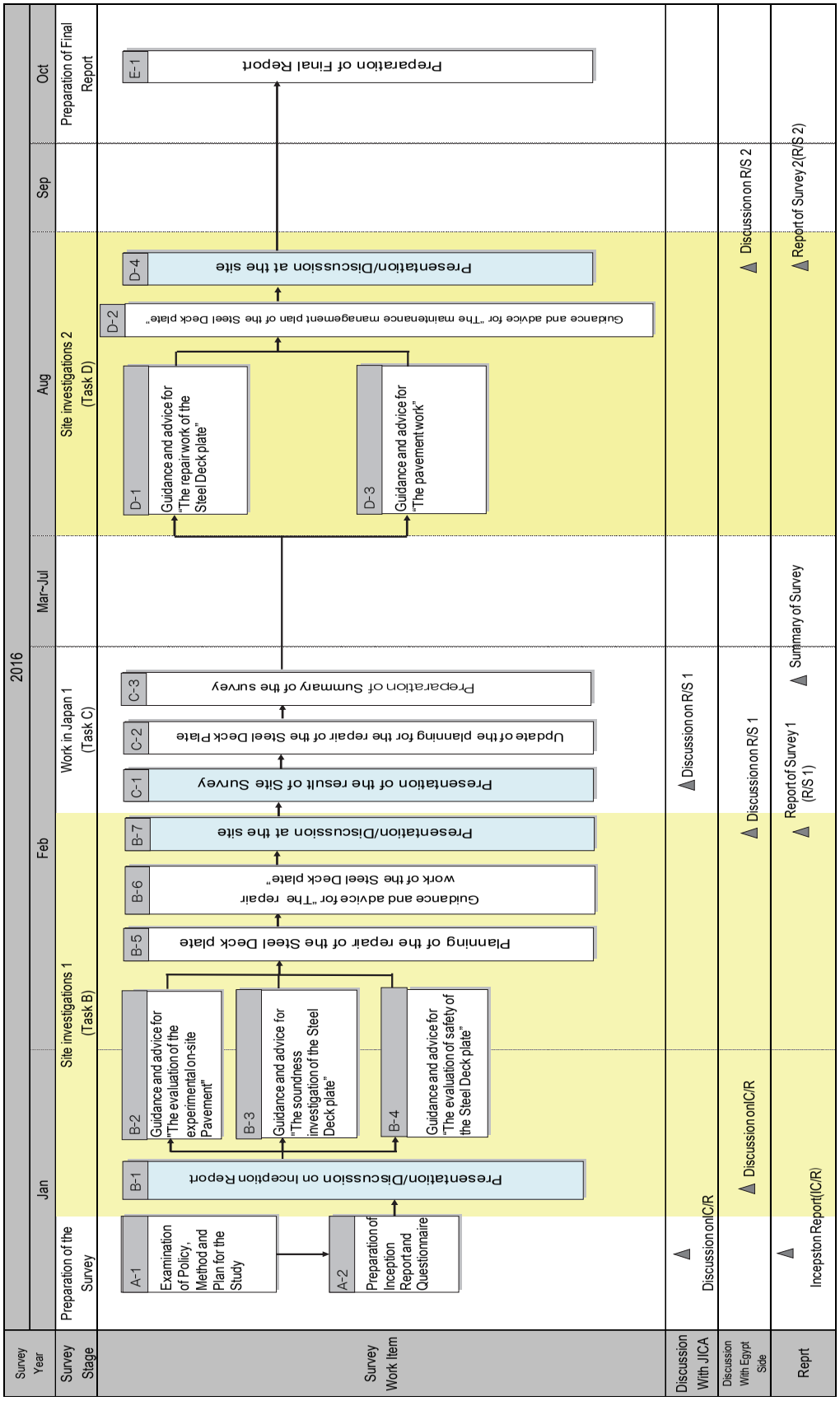
Photo1.2.1 Detailed Inspection for damaged pavement

Photo1.2.2 Corrosion of Steel Deck plate



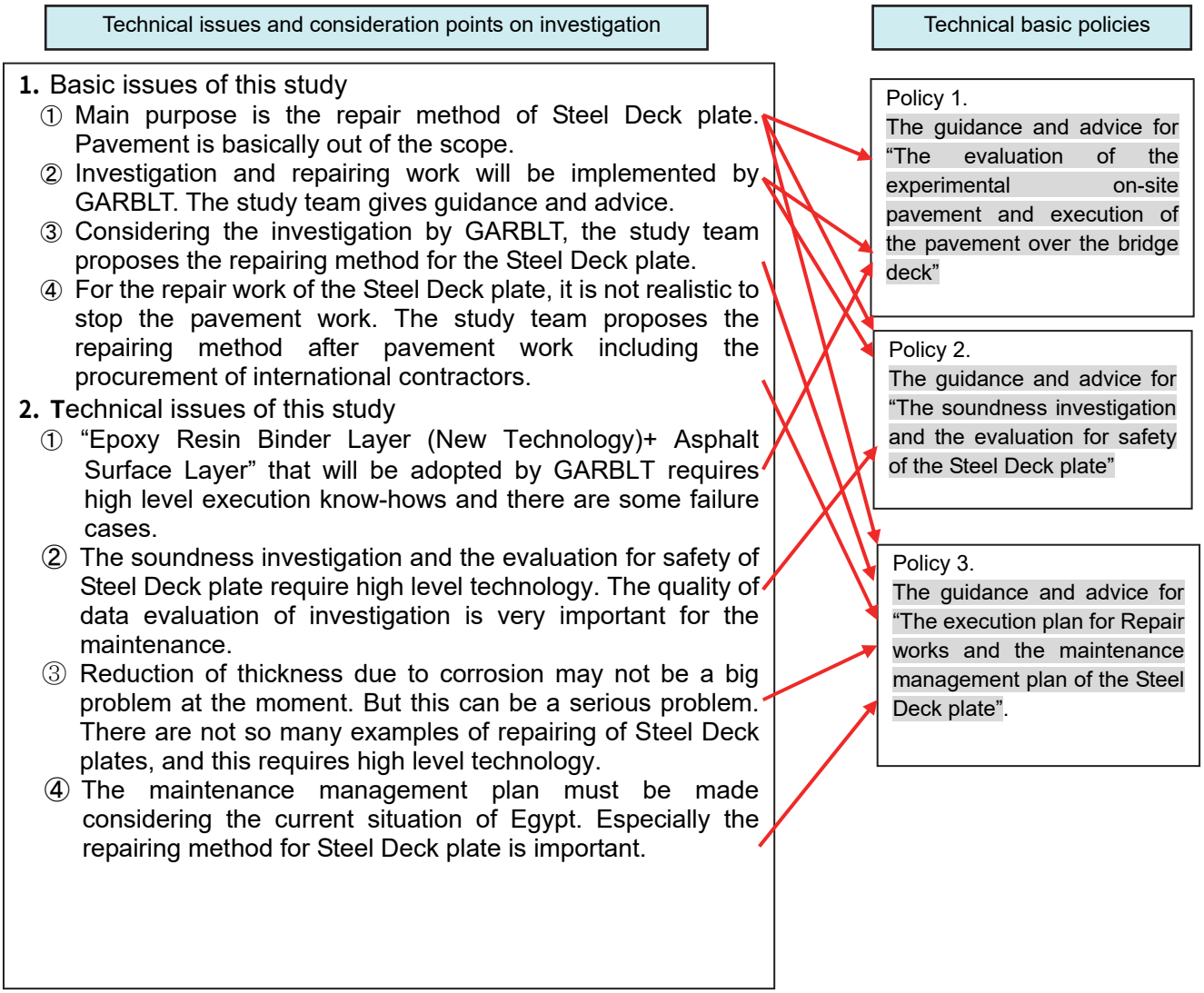
1.3 Summary of the Study

1.3.1 Study Schedule



1.3.2 Study Items

Basic polices regarding technical procedure and operational management are established and summarized by taking into account the background, objectives, and current problems.



(1) Preparation of the Survey (Task A)

Work Item【A-1】 Examination of Policy, Method and Plan for the Study

Work Item【A-2】 Preparation of Inception Report and Questionnaire

(2) Site investigations 1 (Task B)

Work Item【B-1】 Presentation / Discussion on Inception Report

Work Item【B-2】Guidance and advice for "The evaluation of the experimental pavement"

Work Item【B-3】 Guidance and advice for "The soundness investigation of the Steel Deck plate"

Work Item【B-4】 Guidance and advice for "The evaluation for safety of the Steel Deck plate"

Work Item【B-5】 Planning for the repair of the Steel Deck plate

Work Item【B-6】 Guidance and advice for "The repair work of the Steel Deck plate"

Work Item【B-7】 Presentation/Discussion at the site

(3) Work in Japan 1 (Task C)

Work Item【C-1】 Presentation of the result of Site Surve

Work Item【C-2】 Update of the planning for the repairing of the Steel Deck Plate

Work Item【C-3】 Making Summary of the survey

(4) Site investigations 2 (Task D)

Work Item【D-1】 Guidance and advice for "The repair work of the Steel Deck plate"

Work Item【D-2】 Guidance and advice for "The maintenance management plan of the Steel Deck plate"

Work Item【D-3】 Guidance and advice for "The pavement of the Steel Deck"

Work Item【D-4】 Presentation/Discussion at the site

(5) Preparation of Final Report (Task E)

Work Item【E-1】 Preparation of Final Report

1.3.3 Study Area

The area of the Survey is shown in the figure below.

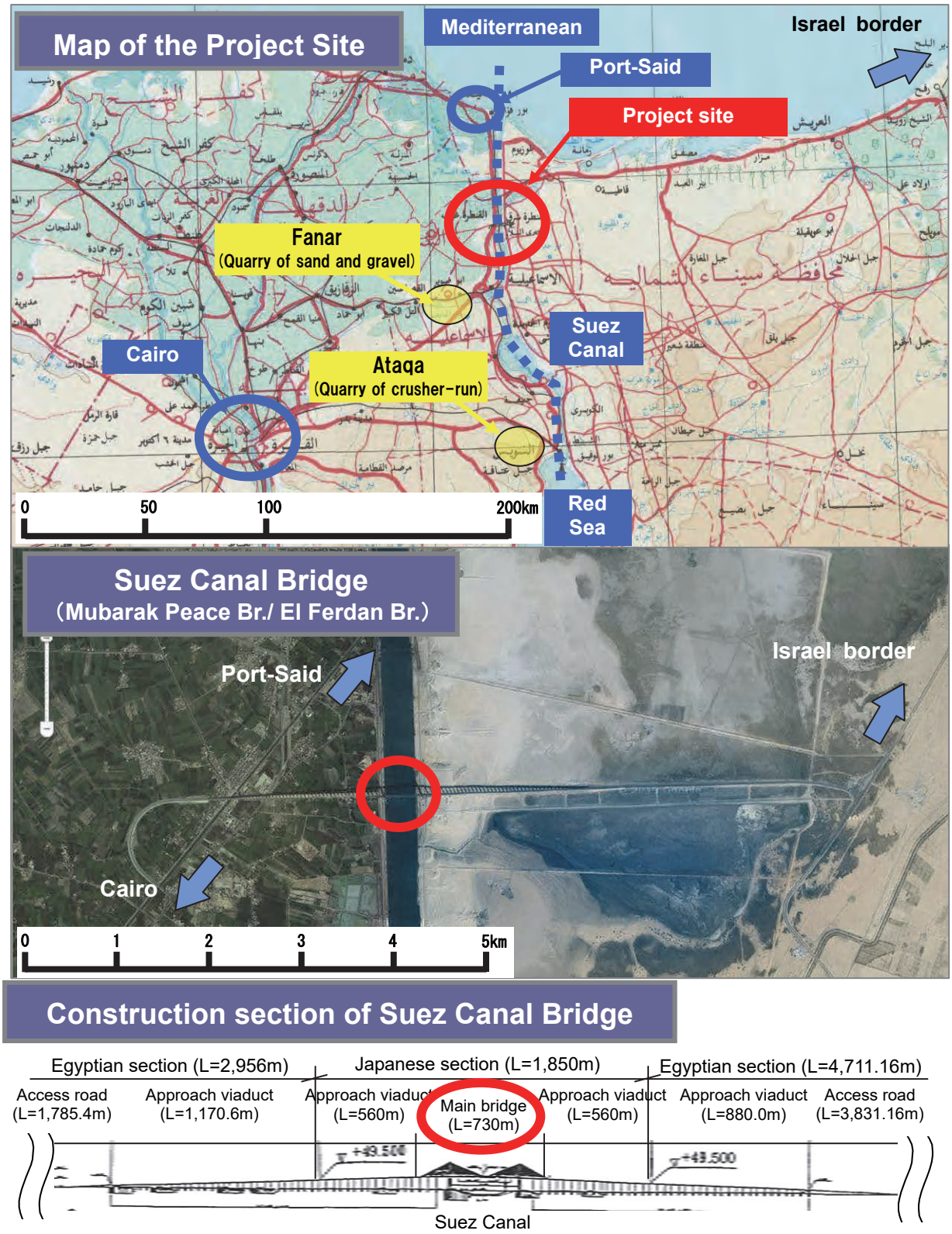


Figure 1.4.1 Survey Area

CHAPTER 2 SITE INVESTIGATION 1

2.1 Executive Summary of Site Investigation

2.1.1 The conclusion of Site survey 1

Site investigation was implemented from 22nd January to 21st February in2016.

The conclusion of Site survey 1 is as follows

1 We cannot guarantee the success of the application of this pavement that was recommended by GARBLT to the Suez Bridge because of our no experience of this type of pavement. But at the same time regarding to the experience of same type of pavement to Masara bridge, we do not oppose your application of this pavement to the Suez Bridge at your own responsibility.

2 Regarding to the result of measurement of deck thickness and the result of survey for fatigue cracks, the repair for the Steel deck doesn't need now.

2.1.2 Others

(1) Surface of Steel Box girder

The Study Team inspected the bridge deck from the inspection vehicle.

The condition of the bridge deck is good partly because of the scarce rain, the good paint, etc. But one severe corrosion was found. It is on the fairing. The fairing is not a structural member so that the bridge will not collapse even if a small part of the fairing disappeared. But it is strongly recommended to remove the rust and repaint the surface immediately.

Site welded fairing part is severely corroded.

Corrosion. The fairing is not a structural member but it is better to remove the rust and repaint immediately.

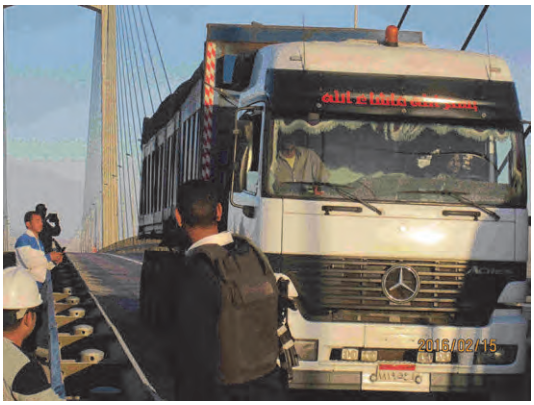
	
Corrosion	Severe corrosion

(2) Heavy trucks

Since September 2002, axle loads of vehicles passing over this bridge have been limited to less than 13 tons. Total weight is limited less than 40ton.Vehicles suspected of excess axle load are measured with the load instruments that are placed near the toll gate. Then, overloaded vehicles are guided to the ferry port on the north side of the Bridge.

During the inspection, heavy tracks of army sometimes have been recognized shown in photos.

Total weight is estimated approximately 60 ton. For the soundness of the bridge especially for the pavement and the Steel Deck plate, axle loads of the tracks of army must be limited to less than 13 tons and the total weight also must be limited to less than 40ton.

	
Heavy Track of Army	Total weight is approximately 60 ton. (2.5m*2.0m*5m*2.0+10.0ton(self-weight) =60ton)

2.2 The Evaluation of the Experimental On-site Pavement

Experimental On-site Pavement wasn't implemented. Also the pull-out tension test wasn't done. So we could not evaluate Experimental On-site Pavement.
The pavement that GARBLT recommended is shown as Fig. 2.2.1.

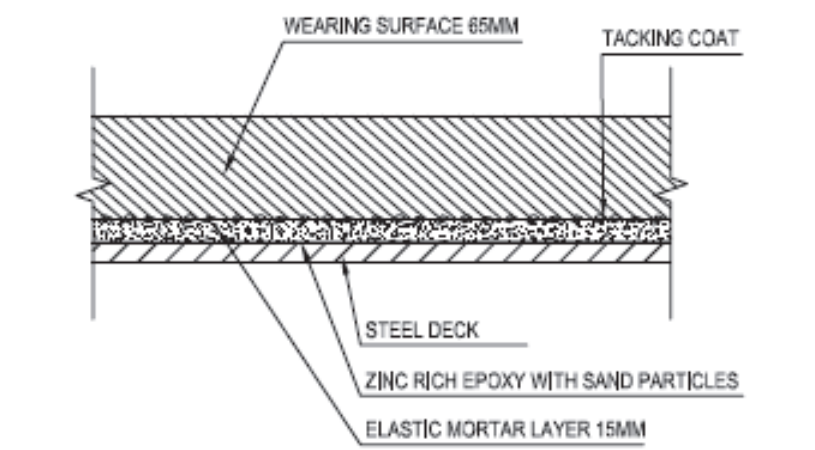


Fig. 2.2.1 Proposed Pavement

We cannot guarantee the success of the application of this pavement that was recommended by GARBLT to the Suez Bridge because of our no experience of this type of pavement. But at the same time regarding to the experience of same type of pavement to Masara bridge, we do not oppose your application of this pavement to the Suez Bridge at your own responsibility.

Outline of the Masara bridge is as follows.

The deck type of the Masara Bridge is steel with U-rib. The structure of the orthotropic steel deck panel adopted for the Maasara Bridge resembles the structure of the orthotropic steel deck adopted for the Suez Bridge.
The Maasara Bridge was constructed in 1988 when the subway was constructed by French Team. The Maasara Bridge which overpasses the subway was also designed by the French Team. The fabrication was also supervised the French team according to Dr. Meguid of ACE consultant. The pavement of the Maasara Bridge was repaved during January 1st to March

22nd, 1994 by the same specification proposed by the ACE consultant for the SUEZ Bridge. Since 1994, the pavement of the Maasara Bridge has shown the good results.

1. The traffic volume is not large but sometimes lager trucks pass.

2 The structure of the orthotropic steel deck panel adopted for the Maasara Bridge resembles the structure of the orthotropic steel deck adopted for the Suez Bridge.

3. Condition of pavement was quite good and no rust was observed on the deck surface. The yellow color shows the Zinc Chromate.

4. Drilled core. The pavement is healthy.

2.3 The Soundness Investigation of the Steel Deck Plate & the Evaluation of Safety of the Steel Deck Plate

2.3.1 Investigation of surface of the Steel Deck plate

Lines of rust were not found. A line of rust can indicate the existence of penetrated fatigue crack from inside of the deck plate.

Non-existence of lines of rust does not assure non-existence of fatigue cracks. Fatigue cracks around U-shaped rib under deck plate need to be checked (mentioned in 2.3.3)

As shown in Fig.2.3.1 & 2.3.2, pavement cracks roughly correspond to the tire passing lines. Also the pavement cracks correspond to the positions of the center of U-ribs, or the center of two adjacent U-ribs. This means that the pavement cracks occur over the plates under which no reinforcing ribs exist. This can be seen from the report of 2012, too.

Pavement cracks may have been caused by the deformation of the steel deck plates over an empty space of the U-rib or an empty space between two adjacent U-ribs.

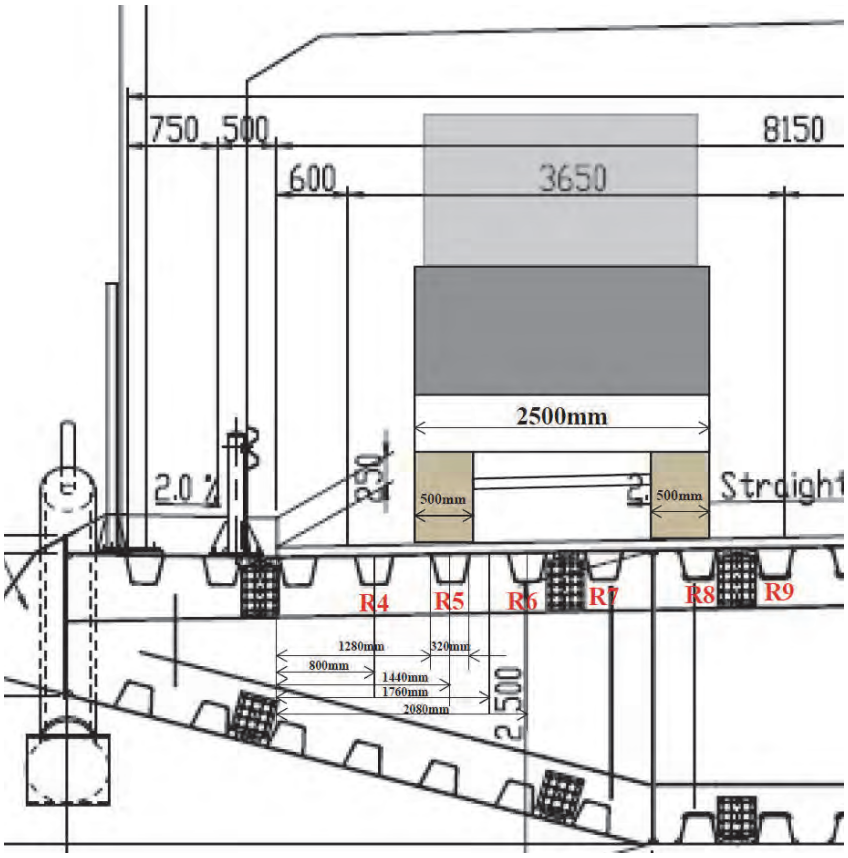


Fig.2.3.1 Distance from Curb to Center of U-ribs or to Center between Two adjacent U-ribs

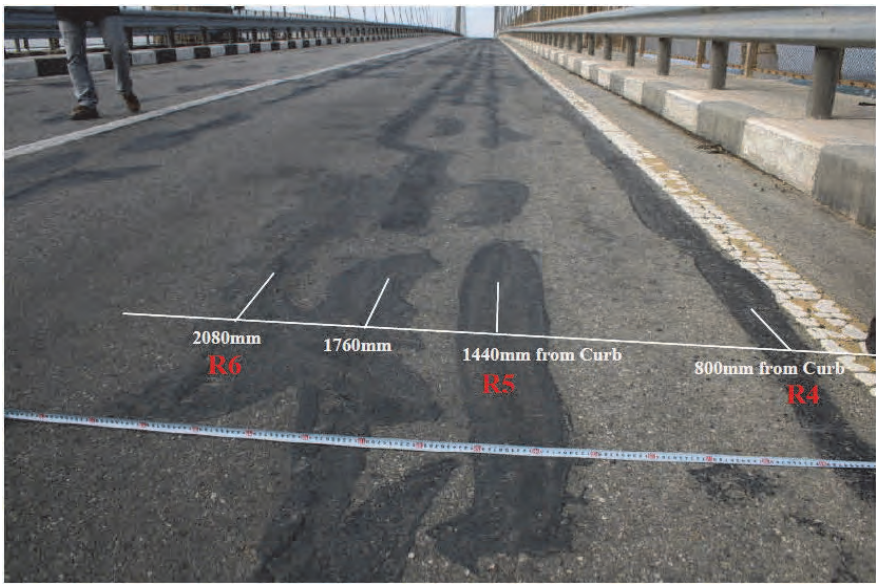


Fig.2.3.2 Pavement Crack Repair Lines and positions of U-ribs

The condition of corrosion is as follows.

The welding line of R4 U-rib below the steel deck, which is 64cm apart from the curb is visible on the left of the brown shoes.

Corroded area near the west tower. This may be worst corroded.

Corrosion near the west tower and on the North Lane.

The corroded areas are on both sides which are below the cracked pavement areas. The center area is healthier.

2.3.2 Thickness Measurement

The area of thickness check is on the North Lane and Western half of the bridge deck. The inspected area is shown on the attached sheet. The result of measurement is shown in the table below. The healthy areas show the original plate thickness of 12mm or the value close to 12mm. But the areas with some corrosions, the surface is not flat and the measurement was unstable. The values more than 12mm may be wrong or incorrect. The worst place is Extra1, whose thickness is shown in red. The place was found after the measurement of all points and was measured to confirm the corrosion. As the surface was not flat, the surface was ground slightly to have a small flat area for the measurement. The thickness was 11.21mm. The measument D6 shown in blue is 11.66mm. This value was 11.97mm. After the measurement of Extra1, D6 was measured again after grinding the surface slightly to have a small flat area. Then the measured value reduced from 11.97mm to 11.66mm. From this result, the corroded areas which show more than 12mm may have the thickness of about the same value as 11.66mm. As it was tried to measure more corroded areas, the measured results may be worse than the real average thickness. From the total area inspection, corrosions are found more on both lane ends and the center of the North lane. Other areas are comparatively healthy.

Table 2.3.1, Measured Plate Thickness west side (mm)

	North Lane (West Bound, Sinai to Ismailia)				
Distance From Bridge end	Point	Center of Bridge			Bridge Edge
		A	B	C	D
15m	1	11.83	11.70	11.70	11.97
30m	2	11.67	11.97	11.85	11.81
55m	3	11.90	12.01	11.76	12.09
58m	Extra1				11.21
80m	4	12.03	11.91	12.17	12.04
115m	5	11.94	11.97	12.06	12.09
150m	6	11.94	12.09	12.01	11.66
163m	Tower				
200m	7	12.10	12.07	11.95	12.01
250m	8	11.88	12.07	11.88	12.01
290m	Extra2	11.85			
300m	9	11.91	12.00	12.15	12.12
350m	10				
365m	Center				

1. Measured area. North Lane .

2. White area is healthier. Rust exists mainly at both ends and at the center.

3. A1 measurement

4. C1 measurement

5. D1 measurement

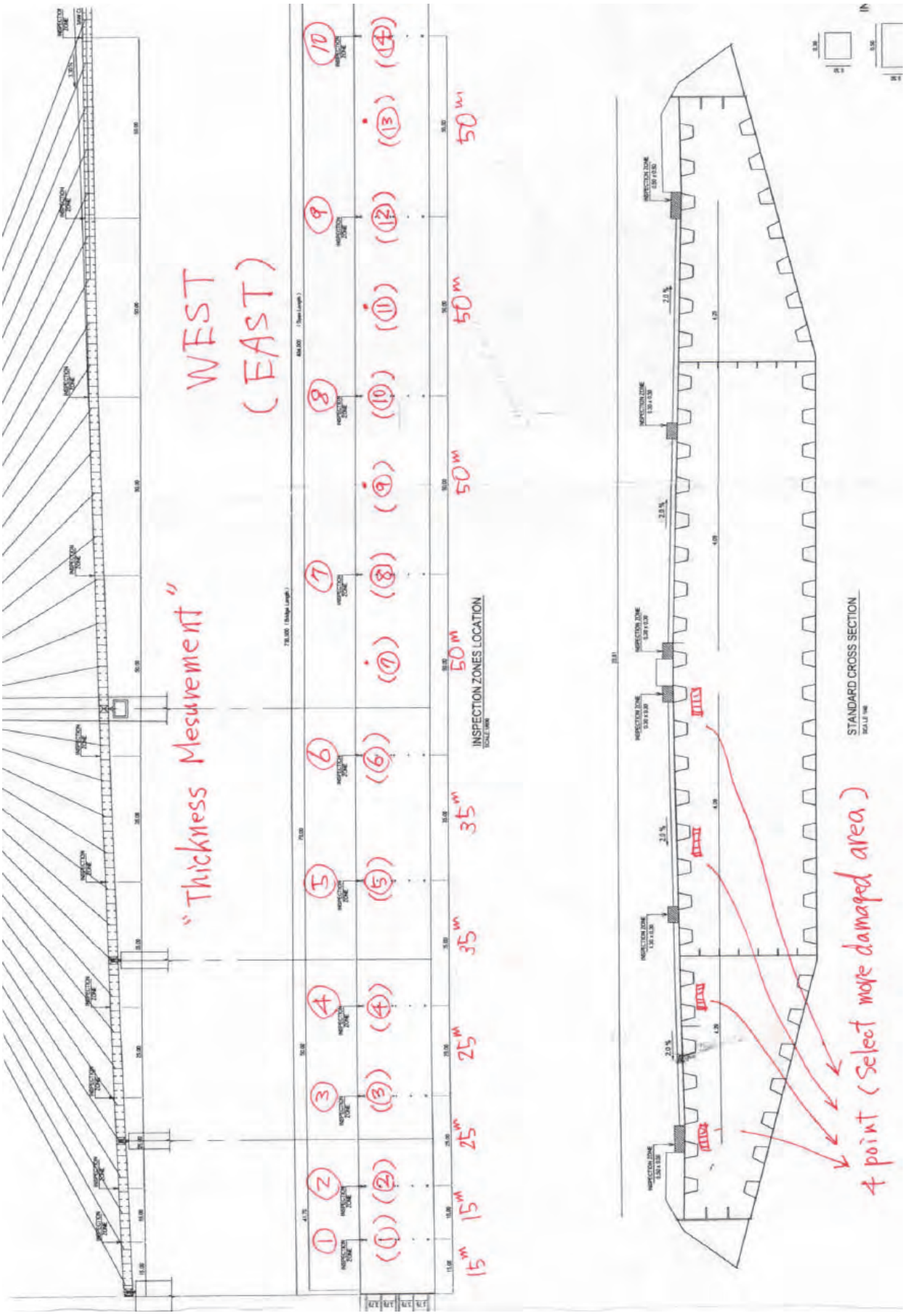
6. A2 measurement

The area of thickness check is on the North Lane and Eastern half of the bridge deck February 18. The result of measurement is shown in the table below.

Table 2.3.2, Measured Plate Thickness of east side (mm)

	North Lane (West Bound, Sinai to Ismailia)				
Distance From Bridge Center	Point	Center of Bridge			Bridge Edge
		A	B	C	D
-30m	1	12.05	11.81	11.77	12.01
-15m	2	11.97	11.84	11.97	11.92
10m	3	12.01	11.97	12.02	12.07
35m	4	11.87	11.89	11.93	11.78
60m	5	11.87	11.98	11.86	11.98
85m	6	11.96	11.95	11.95	12.01
110m	7	11.74	11.22	12.00	11.81
135m	8	11.63	11.75	11.92	11.82
160m	9	11.87	11.75	11.78	11.91
185m	10	12.01	11.88	11.99	11.98
210m	11	11.85	11.84	11.81	11.95
235m	12	11.81	11.69	11.78	11.64
260m	13	11.91	12.05	11.65	11.87
285m	14	11.68	11.51	11.60	11.78
310m	15	11.92	11.91	12.01	11.81
335m	16	11.87	11.99	11.60	11.81
360m	17	11.66	11.34	11.16	11.65
				Average	11.83

	Re-measure after Grinding


WEST
(EAST)
"Thickness Mesurement"
INSPECTION ZONES LOCATION
STANDARD CROSS SECTION
4 point (Select more damaged area)

2.3.3 Investigation of inside of Box Girder

The fatigue cracks tends to appear directly below the tires and the most crack-susceptible U-ribs are examined. The figure below shows the U-ribs which are the most susceptible to fatigue cracks. R5 U-rib may be the most susceptible. In 2012 report, R6 U-rib was examined closely. In addition to R6 U-rib, R5 U-rib should be examined.

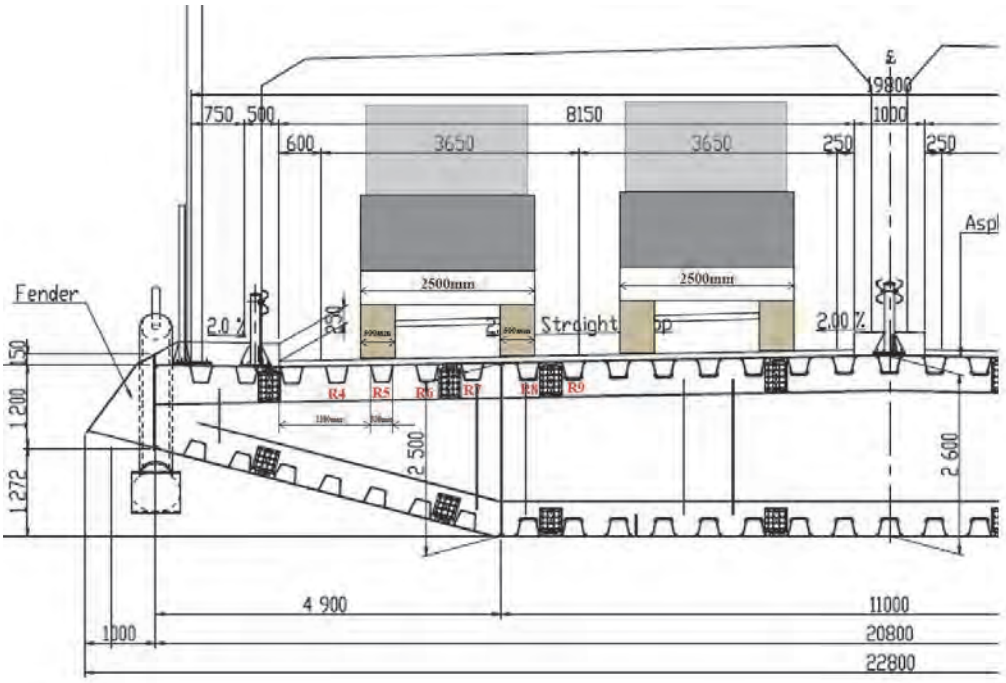


Fig.2.3.3 U-ribs directly under tires.

After entering the inside of the box girder, the places shown in Fig. 2.3.4 were visited. As these places had been examined earlier, if fatigue cracks are found it can be concluded these cracks are formed after 2012. Both R6 and R5 ribs were examined but no indication of cracks, such as the paint cracks were found.

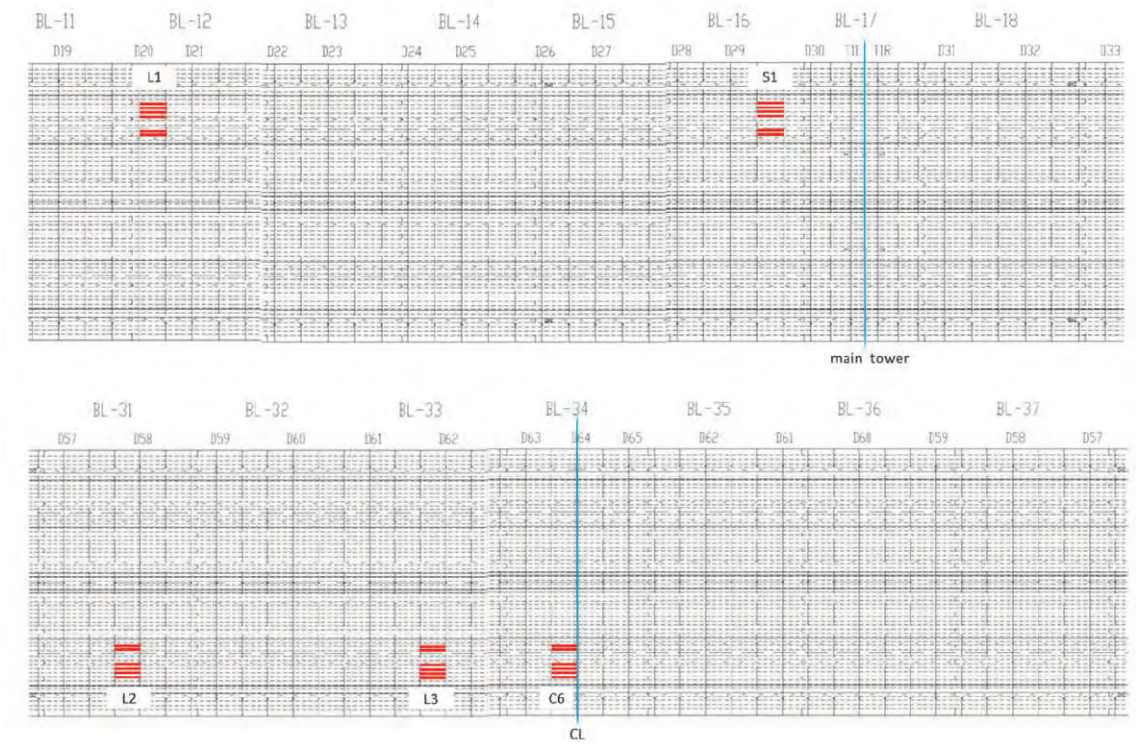
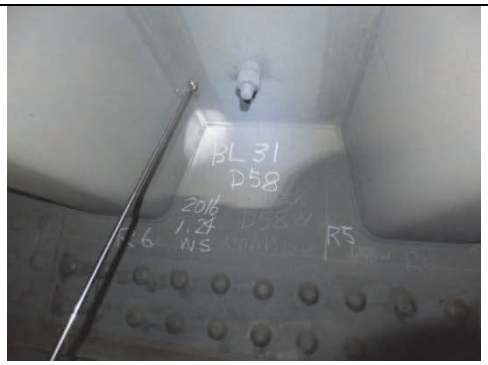


Fig.2.3.4 L1, S1, L2, L3, C6 indicate places investigated in 2012.

1. L1 Position

2. S1 Position



3. L2 Position

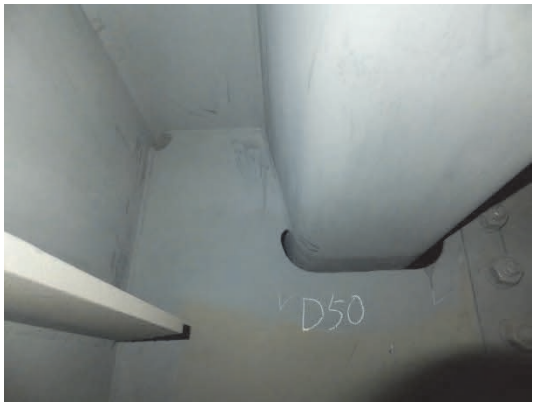
4. L3 Position

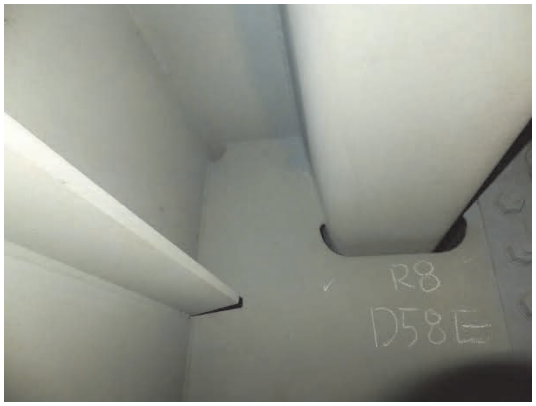
5. C6 Position

The Study Team again inspected inside of the box girder, especially R8 U-rib areas.
The inspected area is the west side span and half of center span.
As a result, no paint cracks nor fatigue cracks were found.

<table>
<tr>
<td> 

R8 and D2 diaphragm, East face.</td>
<td> 

R8 and D2 diaphragm, East face.</td>
</tr>
<tr>
<td> 

D50 diaphragm, east face. No cracks.</td>
<td> 

D58 diaphragm, east face. No cracks.
Above this area, pavement cracks exist.</td>
</tr>
</table>

2.3.4 Conclusion of the investigation

The conclusion of the investigation for Steel Deck plate is as follows.

Regarding to the result of measurement of deck thickness (considering Fig.2.3.5) and the result of survey for fatigue cracks, the repair for the Steel deck doesn't need now.

- With regard to the thickness of the deck plate at 12.0, 11.5 and 11.0 mm, design stress on U-ribs is calculated for each thickness and summarized in Table 4.1.4. As can be seen, regardless of the thickness reduction down to 11.0 mm, stress variance is less than 1% and all stresses calculated are within the range of allowable stress (σa=1400 kg/cm^2) as specified.

Table 2.3.1 Design stress on U-rib (unit : kg/cm^2)

Thickness of Deck Plate	t=12.0mm	t=11.5mm	t=11.0mm
Bending Moment max.	σ= 1097 (1.000)	σ= 1102 (1.005)	σ= 1106 (1.008)
Bending Moment min.	σ= - 1134 (1.000)	σ= - 1139 (1.004)	σ= - 1144 (1.009)

Fig.2.3.5 Report of 2012 study

2.4 The Pavement Work 1

2.4.1 Test working of sand blasting and painting of primer

Test working of sand blasting and painting of primer were implemented at west end point of bridge on February 11th.

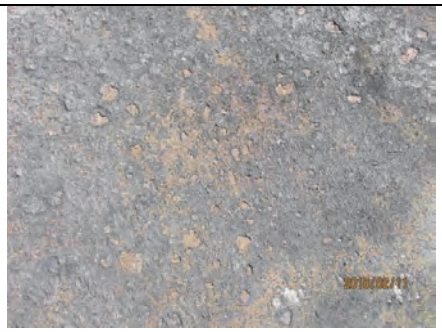
(1) Sand blasting

The surface after sand blasting is almost good. But in some area the corrosion is still remain, so GARBLT ask SAMCO to do sand blasting politely in actual stage. The sand near the bridge was not used because that includes salt.

(2) Painting of primer

Zinc Chromate(Polymar 730CH) is used as primer.
Painting by spray and by roller were compared, then roller method was selected because of workability. Technical date of primer is shown Fig.2.4.1.

1. Testing work of sand blasting



2. Before sand blasting

3. After sand blasting

4. Painting by spray

5. Painting by roller

6 Measurement of thickness;
Approximately 0.15mm at wet condition.
It will be 0.12mm after dried.
A little thick, so it will be reduced more to targeted 0.05mm on actual stage.

شركة الصناعات الكيماوية للبناء « بوليمار »
Chemical Industries For Construction Co." POLYMAR "

الطبقات الإيبوكسية
EPOXY COATINGS
الإيبوكسي متعدد الأغراض
MULTIPURPOSES EPOXY
مواصل التمدد الخاطيه
JOINT SEALANTS
دهانات الحديثة
MODERN PAINTS
جرانيولايت
GRANULITE
مواد عازله ترهويه
WATERPROOFING MATERIALS
المونه الإيبوكسية
EPOXY MORTAR
الإيبوكسي للاصق
EPOXY ADHESIVE
عوازل الأسطح
ROOFING COMPOUNDS
مونه غير قابله للإنكماش
NON - SHRINK GROUT
الإضافات الخرسانية
CONCRETE ADDITIVES
لمركبات اللاصقة
BONDING AGENTS
لاصق السيراميك والقيشاني
TILING ADHESIVES
دهان إيبوكسية ضد الصدأ
ANTICORROSIV EPOXY
مركبات معالجة الخرسانة
CURING COMPOUNDS

POLY POXY 730 Ch.
ZINC CHROMATE EPOXY

POLY POXY 730 Ch. : Is a polyamino amide epoxy paint modified with zinc chromate to provide protection against corrosion for steel structures (steel skeletons and steel bridge decks..etc ...).

TECHNICAL DATA :

Colour	yellow
Mixing Ratio	1 : 5 by weight
Pot life	60 min. at 23° C.
Coverage	300 g/m^2
Shelf life	12 months

DIRECTIONS FOR USE :

* Substrate must be dry and free of oil and other impurities.
* Substrate must be free of rust. Sand plasting is recommended.
* The 2 components must be thoroughly mixed together just before application.
* Apply by brush, roller or spray.
* Apply perpendicularly in case of double coatings.

PACKAGES :

5 kgs, or doubles.

For More details ... Consult our technical service section

FACTORIES : EL - SADAT CITY, 3rd AREA.
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٧٦ – 76

Fig.2.4.1 Technical date of primer

2.4.2 Sand blasting and painting of primer

Sand blasting and painting of primer started February 13rd from center of bridge to west side. Sand blasting takes so much time, so GARBLT and ACE consultant ask SAMCO to increase sand blast machines and workers.

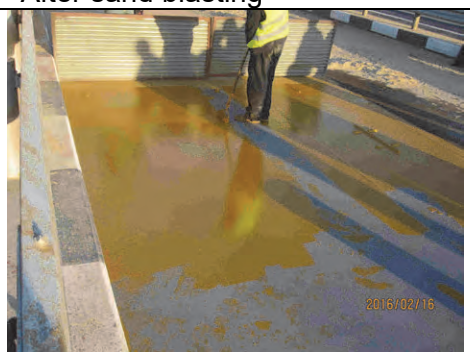
1. Work of sand blasting

2. Sand for sand blasting

3. After sand blasting

4. After sand blasting

5. After sand blasting



6 Painting of primer(Zinc Chromate)

7. After painting of primer

8. After painting of primer

CHAPTER 3 SITE INVESTIGATION 2 (SOUTH SIDE)

3.1 Executive Summary of Site Investigation

Pavement Work of North Side;

1. Pavement Work of North Side was finished in August, and opened to the traffic.

   The condition of the pavement looks very good.

   Monitoring of the pavement must be implemented constantly.

The surface of pavement of North Side.

The pavement around expansion joint of East end.

The Site investigation was carried out from 31st August to 8th September, 2016.

The conclusion of the Site survey 2 is as follows;

2. According to the result of measurement of deck thickness and the result of survey for fatigue cracks, the repair of the steel bridge deck is not needed at present.

3.2 The Soundness Investigation of the Steel Deck Plate & the Evaluation of Safety of the Steel Deck Plate (South-Side)

3.2.1 Investigation of surface of the Steel Deck plate

The pavement removing work is very smooth because of the experience of workers on North Side. The cutting of pavement is stopped about 2cm above the steel deck surface, so that the over cutting of the steel deck would not happened.

Lines of rust were not found. A line of rust can indicate the existence of penetrated fatigue crack from inside of the deck plate.

Non-existence of lines of rust does not assure non-existence of fatigue cracks. Fatigue cracks

around U-shaped rib under deck plate need to be checked. (mentioned in 3.2.3)

 Removal of pavement.	 Cutting section (2cm remaining).
 Surface of Steel Deck (Before cleaning)	 Corrosion near southern edge (Before cleaning)
 Surface of Steel Deck (After cleaning)	 Deep corrosion (After cleaning)

3.2.2 Thickness Measurement

The result of measurement is shown in the table below. The healthy areas show the original plate thickness of 12mm or the value close to 12mm. But the areas with some corrosions, the surface is not flat and the measurement was unstable. So the surface was ground slightly to have a small flat area for the measurement.

The reduction of thickness of deck plate of South side is a little bigger than that of North side.

Table 3.2.1 Measured Plate Thickness (mm)

	South Lane (East Bound, Ismailia to Sinai)				
Distance From Steel Box End of East(m)	Point	Center of Bridge			Bridge Edge
		A	B	C	D
0.5	1	11.75	11.73	11.45	11.73
25.0	2	11.66	11.81	11.78	11.79
50.0	3	11.95	11.72	11.67	11.93
75.0	4	11.75	11.75	11.60	11.64
100.0	5	11.08	11.91	11.48	11.99
125.0	6	11.64	11.49	11.72	11.44
150.0	7	11.94	11.05	11.76	11.52
175.0	8	11.91	11.45	11.87	12.11
200.0	9	11.66	11.15	11.90	11.75
225.0	10	11.62	11.44	12.00	11.93
250.0	11	11.70	11.22	11.56	11.61
275.0	12	11.93	11.27	11.57	11.78
300.0	13	11.95	11.82	11.31	11.80
325.0	14	12.00	11.75	11.62	11.80
350.0	15	11.92	11.97	11.48	12.06
375.0	16	11.93	11.94	11.81	11.85
400.0	17	11.95	12.02	11.60	11.94
425.0	18	11.81	11.06	11.57	11.84
450.0	19	12.11	12.02	11.44	12.00
475.0	20	12.03	12.07	11.76	11.90
500.0	21	11.94	11.97	12.05	11.95
525.0	22	12.16	11.67	11.51	11.52
550.0	23	12.05	11.99	11.54	11.60
575.0	24	11.85	11.54	11.52	1.99
600.0	25	11.58	11.22	11.51	11.51
625.0	26	11.90	11.28	11.97	12.19
650.0	27	11.87	11.23	11.66	11.54
675.0	28	11.50	11.21	11.13	11.67
700.0	29	11.55	11.95	11.79	11.95
725.0	30	11.39	11.54	11.78	11.90
150−0.5m			11.35		
150+0.5m			11.00		
150(B−1.0m to A)			11.26		
				AVE=	11.63

. Measurement point of cross section

Measurement point after cleaning

Grinding

The surface after grinding

Measurement work

Measured thickness

3.2.3 Investigation of inside of Box Girder

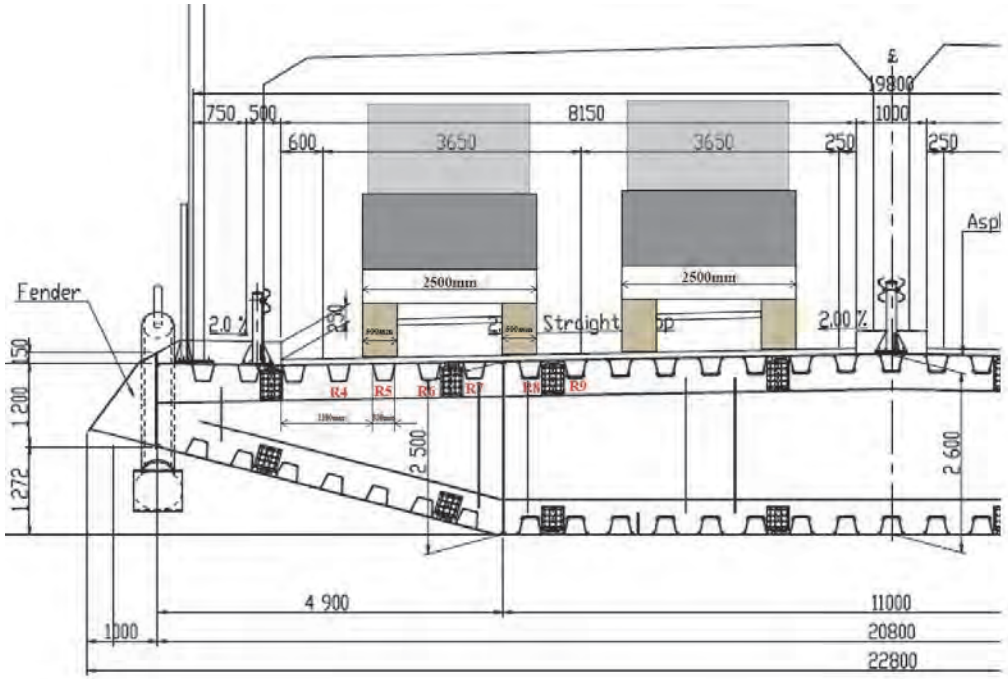
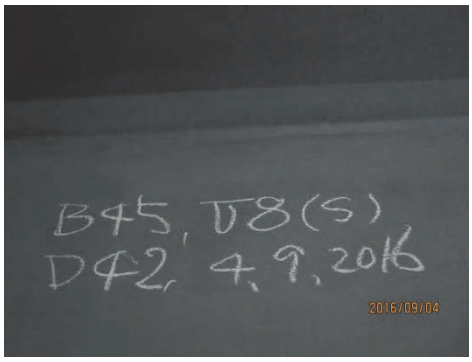
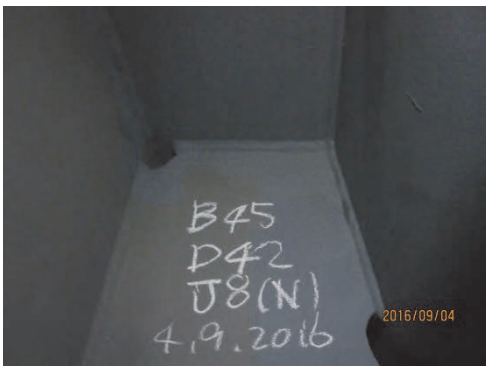


Figure 3.2.2 U-ribs directly under tires.

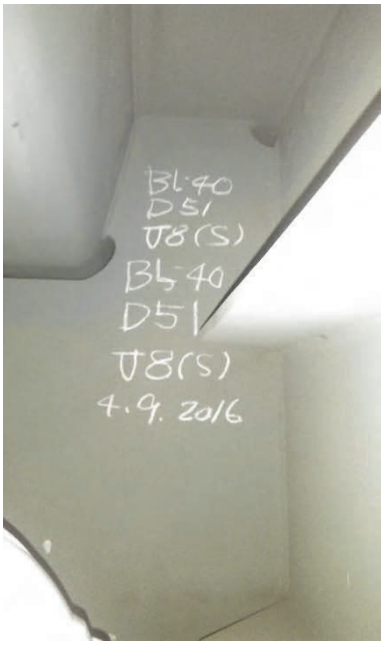
After entering the inside of the box girder, the places shown in Figure 3.2.3 were visited (from BL40 to BL65). R8 ribs (South & North) were examined but no indication of cracks, such as the paint cracks were found.



BL45 D42, U8 (South).



BL45 D42, U8 (North). .



BL40 D51, U8 (South).

BL55 D23, U8 (South).

BL60 D14, U8 (South).

BL65 D5, U8 (South).

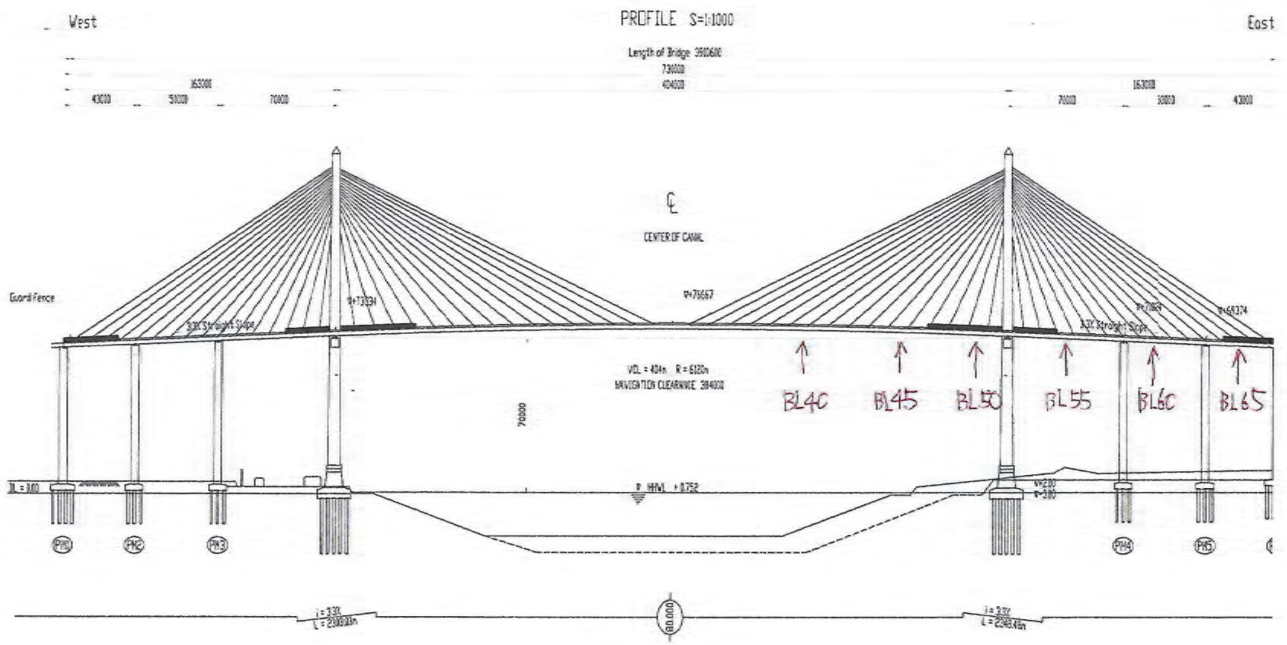


Figure 3.2.3 Investigation points.

3.2.4 Conclusion of the investigation

The conclusion of the investigation for Steel Deck plate is as follows.

Regarding the result of measurement of deck thickness (shown in Table 3.2.1) and the result of survey for fatigue cracks, the repair of the Steel deck is not needed in the same manner as North Side.

- With regard to the thickness of the deck plate of 12.0, 11.5 and 11.0 mm, design stress on U-ribs is calculated for each thickness and summarized in Table 4.1.4. As can be seen, regardless of the thickness reduction down to 11.0 mm, stress variance is less than 1% and all stresses calculated are within the range of allowable stress (σa=1400 kg/cm^2).

Table 4.1.4 Design stress on U-rib

(unit : kg/cm^2)

Thickness of Deck Plate	t=12.0mm	t=11.5mm	t=11.0mm
Bending Moment max.	σ= 1097 (1.000)	σ= 1102 (1.005)	σ= 1106 (1.008)
Bending Moment min.	σ= - 1134 (1.000)	σ= - 1139 (1.004)	σ= - 1144 (1.009)

Figure 3.2.4 Results from 2012 study report

3.3 The Maintenance Management Plan

(1) Pavement

The pavement work (Type recommended by GARBLT) was finished in North Side. The condition of pavement is looks very good. But the monitoring of the pavement must be implemented constantly. If the serious damage is happened again, the alternative method must be studied.

JICA study team recommend Guss Asphalt Pavement based on the experience in Japan. Meanwhile, in Europe "Mastic Asphalt" is used popularly for steel deck plate. The quality of "Mastic Asphalt" is closely the same as Guss Asphalt. "Mastic Asphalt" is mentioned in BS 1447.

"Mastic Asphalt" will be used for Izumit Bay bridge in Turkey. Formation of this bridge is as follows.

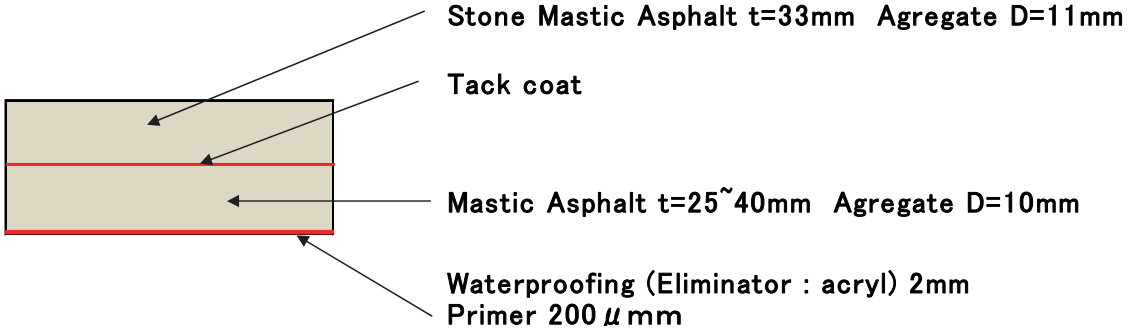


Figure 3.2.5 Cross Section of "Mastic Asphalt" pavement

(2) The Repair Plan for the Steel Deck plate

The conclusion of the investigation for Steel Deck plate is as follows.

According to the result of measurement of deck thickness and the result of survey for **f**atigue cracks**, the repair for the Steel deck is not needed now.**

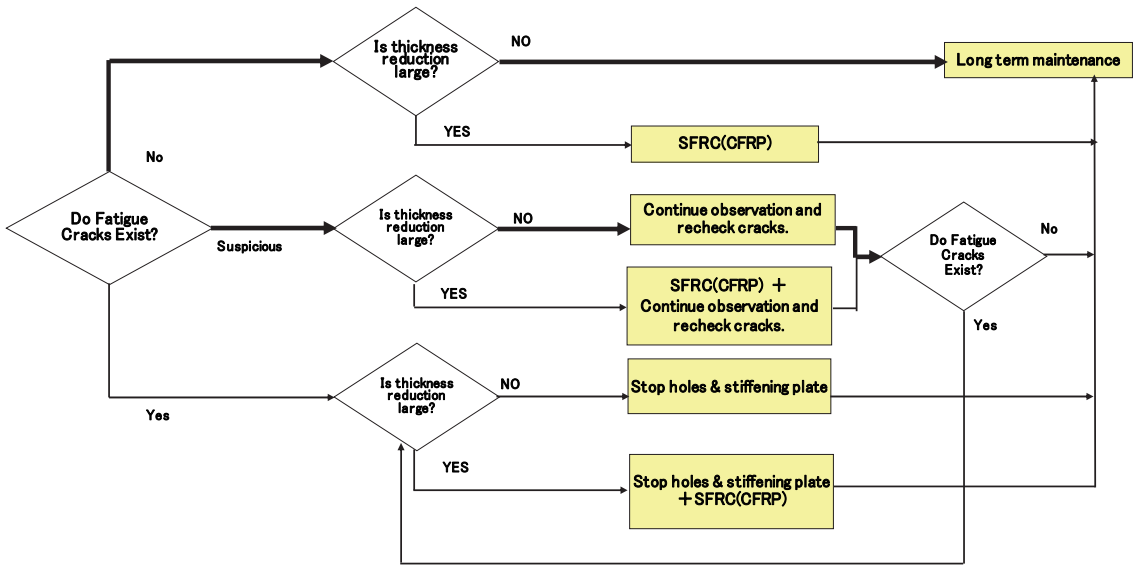
Then “The Long term management” shall be implemented according to the flowchart (Figure 3.2.6),.

Important items of “Long term management” for Steel Deck plate is as follows.

a. Checking cracks of the pavement
- At least once a month
- If the cracks over 1cm width are spread over some area and occupied 30 % of the area, the following investigation must be implemented.
  1 Removal of the 2m*2m area of pavement.
  2 Checking the surface of Steel Deck (Adhesion between pavement & Deck, Corrosion of the Deck).
  3 Measurement of the thickness of the Steel Deck.

b. Checking the fatigue cracks inside box girder
- At least once a half year

c. Study of the necessity of Repair and Reinforcement for the Steel Deck plate



Note; This flow assumes the good result of pavement application. If the result is not good, the investigation of suitable pavement methods is needed.

Selection of Reinforcing Method of Orthtropic Steel Deck

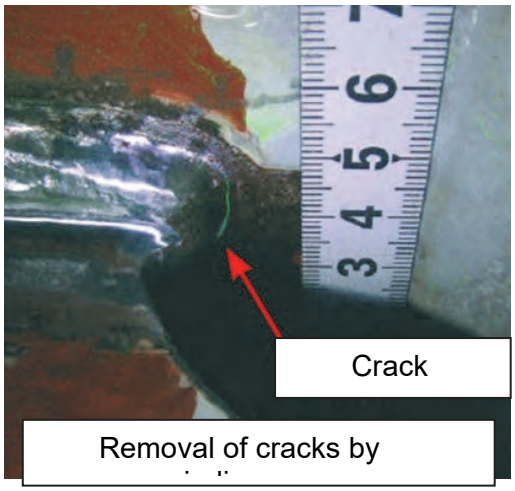
Figure 3.2.6 Flowchart for the repair of Steel Deck plate

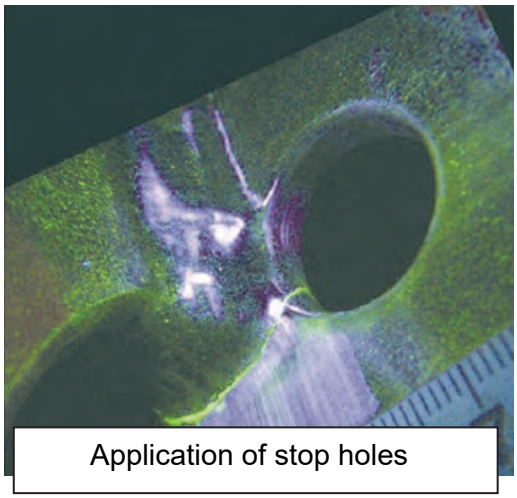
(3) The Reinforcement method of the Steel Deck plate

Fatigue cracks are critical damages for Steel Deck plate. Therefore if fatigue cracks are found, the repair of the cracks (3-1) and the reinforcement of whole Steel Deck (3-2 to 3-4) must be implemented immediately. Because the possibility of the further progress of fatigue cracks in the near future is very high. If fatigue cracks are found, immediately contact fatigue crack specialists and do not try to repair fatigue cracks by yourselves without the consultation of the specialists. If fatigue cracks are found, immediately impose some traffic restrictions over the bridge to reduce the heavy traffic.

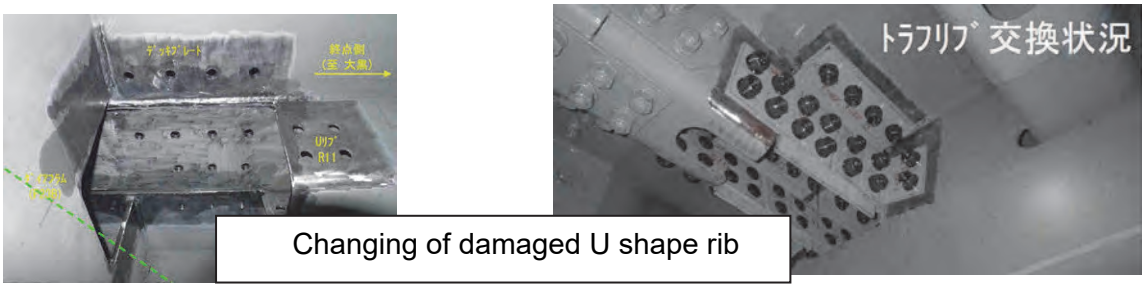
Repair of fatigue cracks will be shown in 3-1. Reinforcement of the Steel deck will be shown in 3-2, 3-3, 3-4. Methods shown in 3-3, 3-4 are being investigated, the method 3-3(SFRD??) would be most suitable based on the experiences.

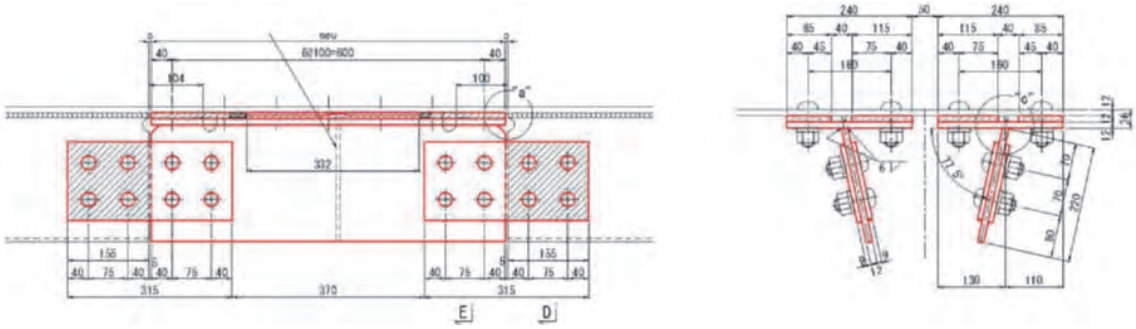
3-1 Repair of fatigue cracks



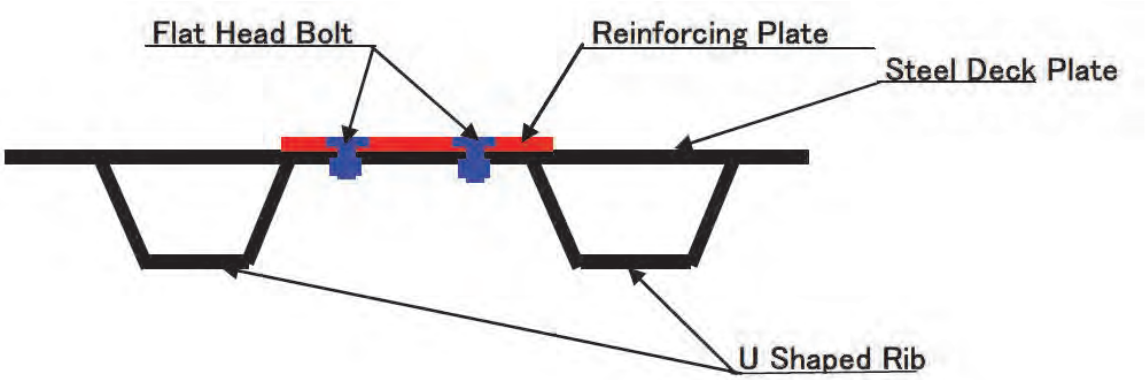


Repair of Crack (Removal and reinforcement of U-Rib)



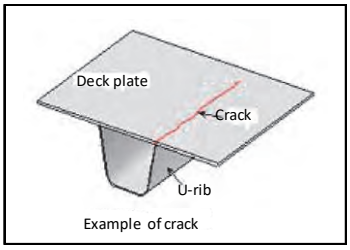


Repair of Crack (Cracks of Deck Plate)

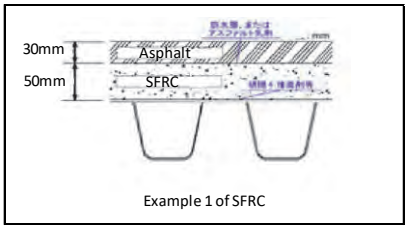


3-2 SFRC (Reinforcement of Steel Deck)

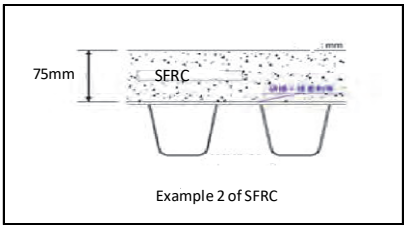
SFRC(Steel Fiber Reinforced Concrete) was developed in Japan to prevent fatigue cracks and to reduce the deflection. The highly durable epoxy resin adhesive between the steel deck plate and the steel fiber reinforced concrete achieves the unity of the deck plate and the concrete. SFRC can be applied with the conventional equipment.



Example of crack

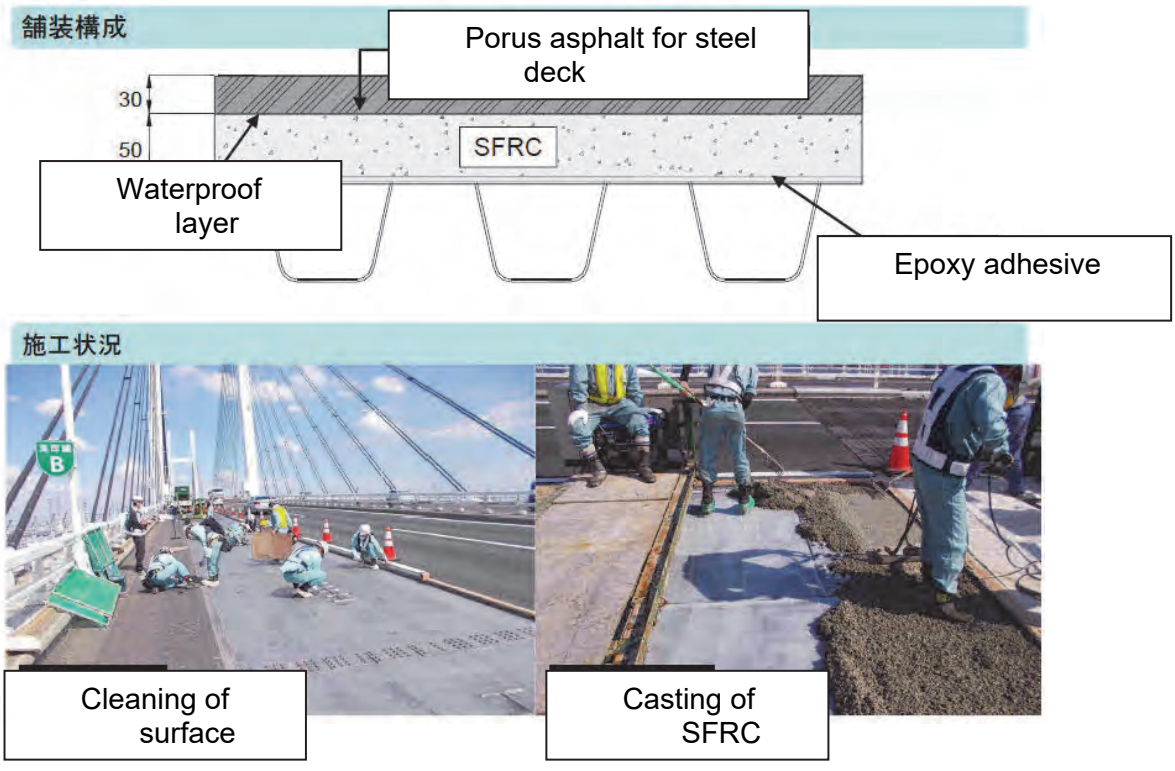


Example 1 of SFRC



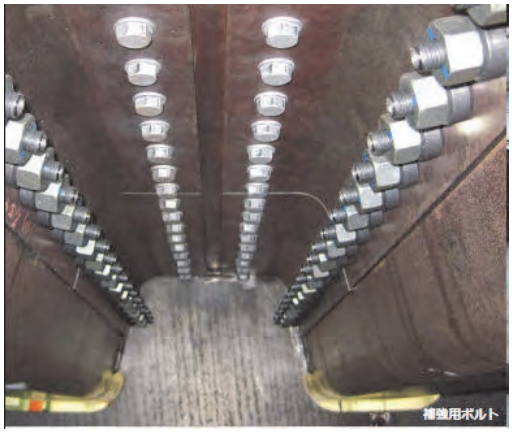
Example 2 of SFRC

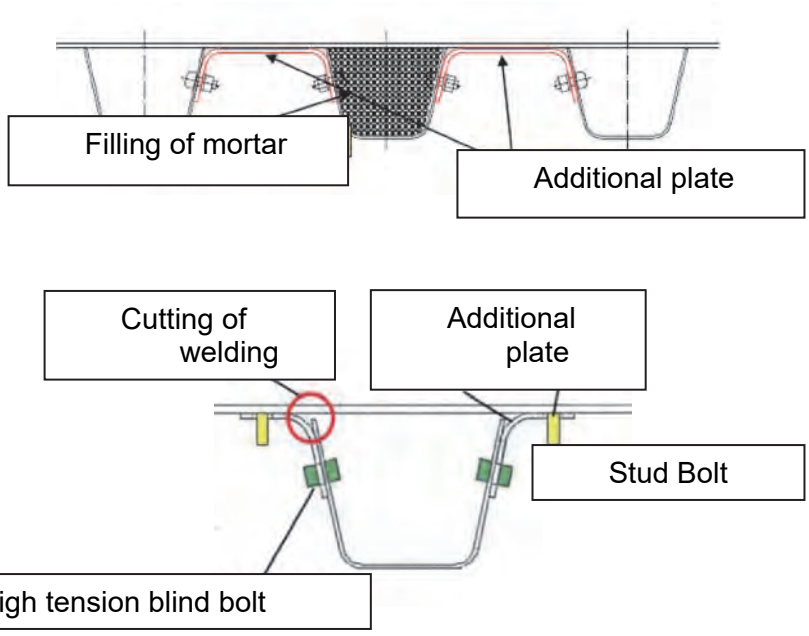
In the beginning, stud bolts were utilized for the connection between the Steel Deck plate and SFRC. But cracks were found around the stud bolts and stud bolts are not utilized anymore.

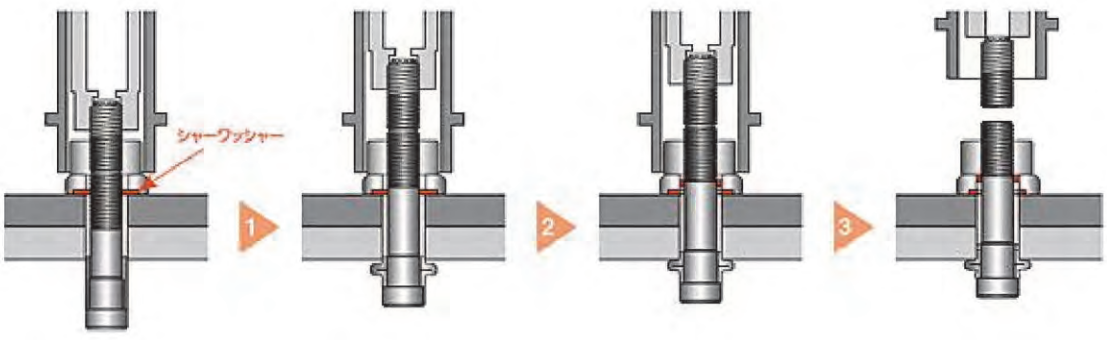


3-3 Reinforcement of steel deck plate from under-side

This method is to reinforce the steel deck plate only from the under-side and the traffic restriction is not needed.
This method is being studied in Japan.



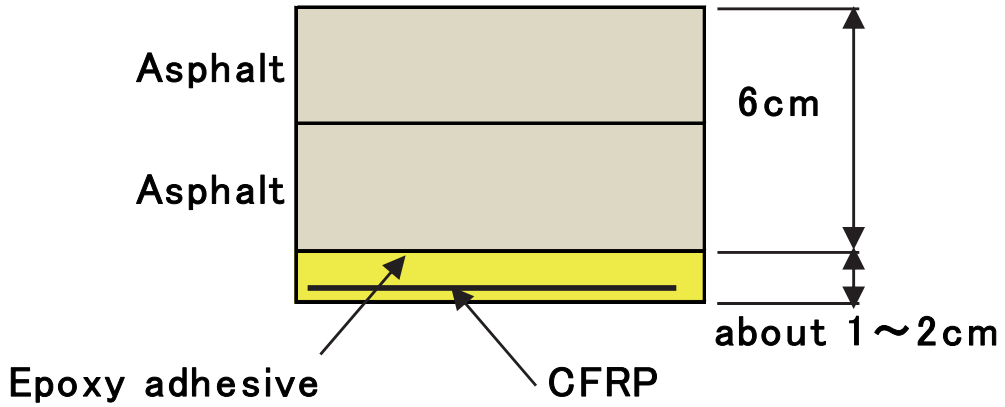




High tension blind bolt

3-4 CFRP (Reinforcement of Steel Deck)

CFRP is popularly used to repair and to reinforce RC slabs, RC&PC girders and Steel girders internationally. In Japan CFRP is also used to reinforce the surface of bridges.
CFRP can resist the tension only. There are no experiences of adoption for Steel Deck reinforcement. If CFRP is used properly, CFRP can decrease the deformation of the steel deck.
To adopt CFRP for the reinforcement of steel decks, a further study of CFRP is needed.



CHAPTER 4 CONCLUSION AND RECOMENDATION

4.1 Executive Summary of Site Investigation

4.1.1 Pavement

The pavement work (Type recommended by GARBLT) was finished in North Side. The condition of pavement looks very good. But the pavement condition must be monitored constantly. If serious damages happen again, the alternative methods must be studied.

4.1.2 The Soundness Investigation of the Steel Deck Plate & the Evaluation of Safety of the Steel Deck Plate

1 The summery of measured Plate Thickness of Steel Deck plate is as follows.

mm

Average Thickness	North Side	11.87
	South Side	11.63
	Total	11.74
Minimum Thckness	North Side	11.16
	South Side	11.00

According to the Report of 2012 study (Checking of the stress of Steel Deck), Reduction of Steel Deck plate is not critical in this stage.

2 Investigations of inside of Box Girder for fatigue cracks (24th & 27th Jan, 4th Sep 2016), there were no indication of fatigue cracks.

According to the measured Plate Thickness of Steel Deck plate and the result of checking of fatigue cracks, the repair for the Steel deck is not needed at present.

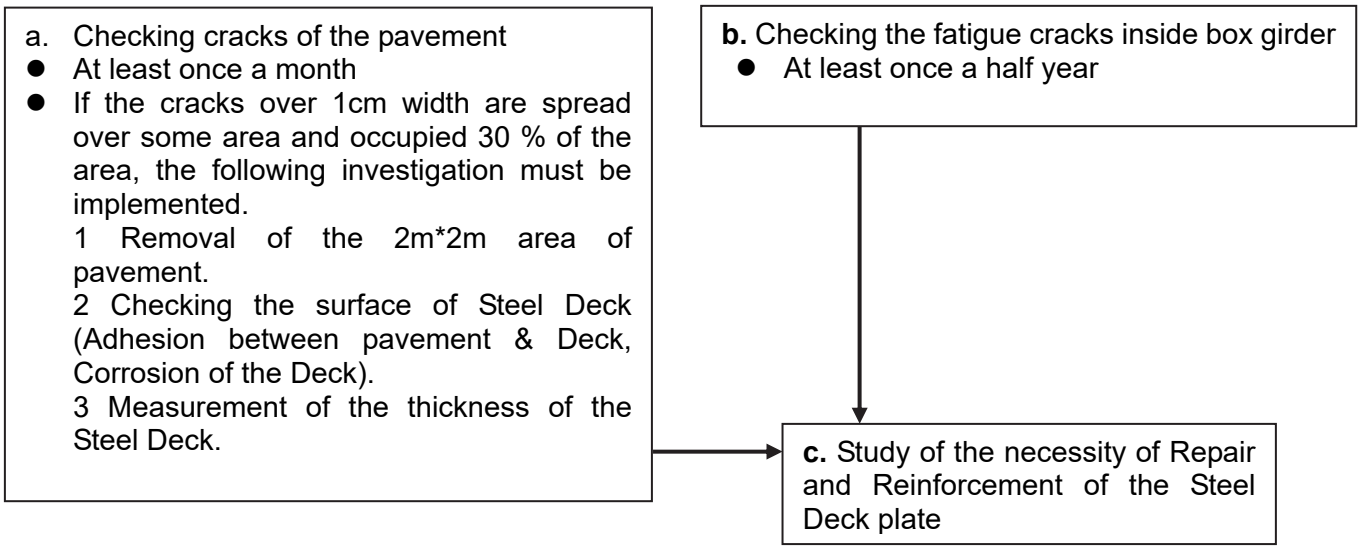
4.2 Recommendation

4.2.1 Management and Repair & Reinforcement of Steel Deck plate

According to the result of measurement of deck thickness and the result of survey for **f**atigue cracks**, the repair for the Steel deck is not needed at present.**

Then “Long term management” shall be implemented instantly.

Important items of “Long term management” for Steel Deck plate is as follows.



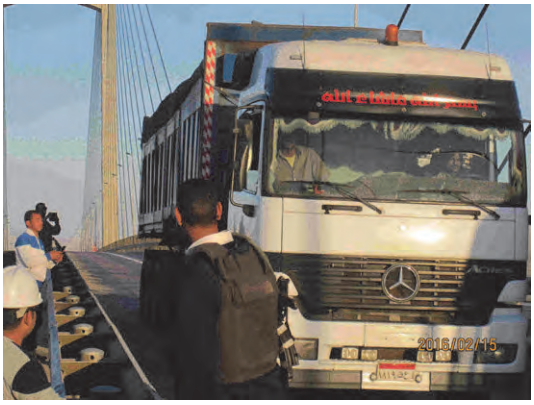
a. If the thickness of Steel Deck plate will be reduced below 10mm, the stress of the Steel Deck must be calculated strictly and the soundness of the steel deck must be evaluated.

b. If fatigue cracks are found, not only the repair of the cracks but also the reinforcement of whole Steel Deck must be implemented immediately. Because the possibility of occurrence of another fatigue cracks in the near future is very high.

4.2.2 Heavy trucks

Since September 2002, axle loads of vehicles passing over this bridge have been limited to less than 13 tons. Total weight is limited less than 40ton.Vehicles suspected of excess axle load are measured with the load instruments that are placed near the toll gate. Then, overloaded vehicles are guided to the ferry port on the north side of the Bridge.

During the inspection, heavy tracks of army sometimes have been recognized shown in photos.
Total weight is estimated approximately 60 ton. For the soundness of the bridge especially for the pavement and the Steel Deck plate, axle loads of the tracks of army must be limited to less than 13 tons and **the total weight also must be limited to less than 40ton**.

	
Heavy Track of Army	Total weight is approximately 60 ton. (2.5m*2.0m*5m*2.0+10.0ton(self-weight) =60ton)

Appendix

Contents

APPENDIX 1 VISUAL INSPECTION OF SURFACE & INSIDE OF STEEL DECK PLATE

Saturday January 23rd, 2016

At the Suez Canal Maintenance Office from 11PM

The General Manager, Mr. Aly Elsafty Abdalla, engineers of ACE consult and, SAMCO and JICA team visited the bridge to see the removal of the pavement.

1. Bridge and pavement removal

2. One lane of pavement is removed. The condition of the steel deck surface is checked. If blasted, it is difficult to find fatigue cracks so that the steel deck surfaced was checked before blasting.

3. Some rust is found but not so severe.

4. Removed pavement surface directly attached to steel deck.

5. Spot rust after rust removal. A technician tried to flatten surface by grinder but JICA team stopped grinding, because healthy plate must not be ground.

6. Plate thickness next to spot rust. There is 12mm.

Sunday January 24th, 2016

The fatigue cracks tend to appear directly below the tires and the most crack-susceptible U-ribs are examined. The figure below shows the U-ribs which are the most susceptible to fatigue cracks. R5 U-rib may be the most susceptible. In 2012 report, R6 U-rib was examined closely. In addition to R6 U-rib, R5 U-rib should be examined.

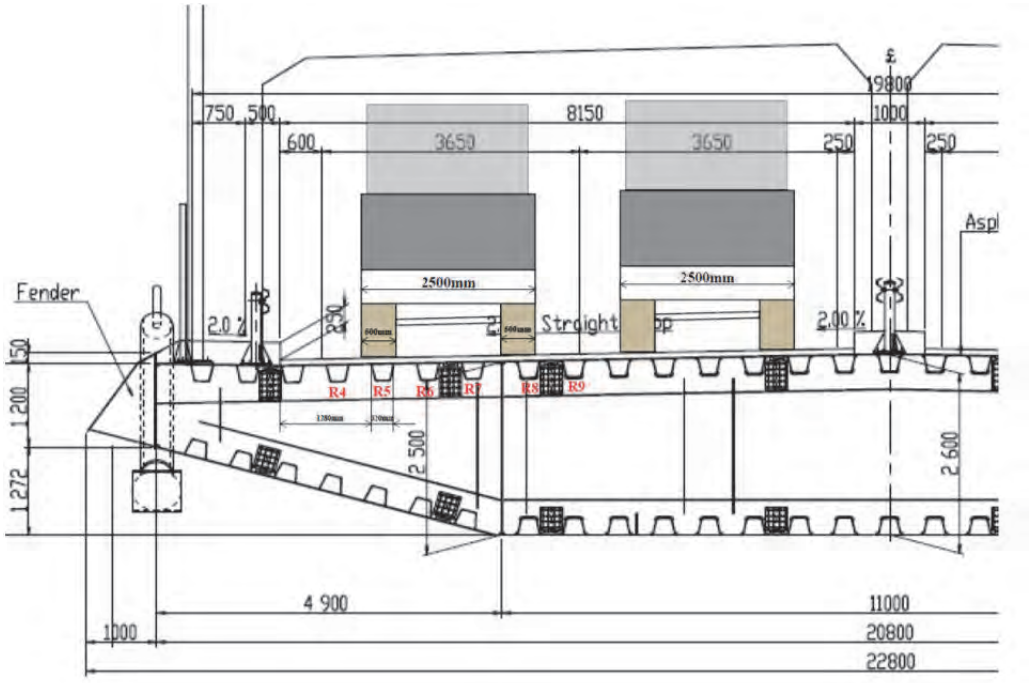


Fig.1 U-ribs directly under tires.

After entering the inside of the box girder, the places shown in Fig. 2 were visited. As these places had been examined earlier, if fatigue cracks are found it can be concluded these cracks are formed after 2012. Both R6 and R5 ribs were examined but no indication of cracks, such as the paint cracks were found.

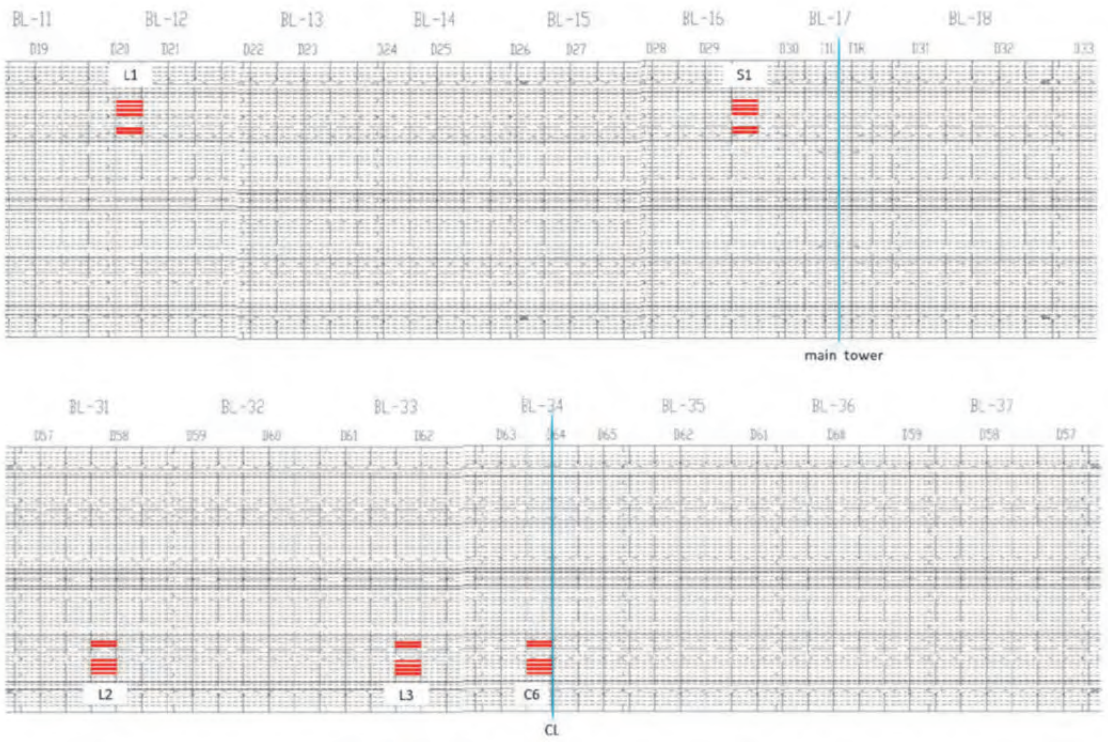


Fig.2　L1, S1, L2, L3, C6 indicate places investigated in 2012.

<table>
<tr>
<td> 

1. L1 Position</td>
<td> 

2. S1 Position</td>
</tr>
<tr>
<td> 

3. L2 Position</td>
<td> 

4. L3 Position</td>
</tr>
<tr>
<td> 

5. C6 Position</td>
<td> 
6. Entrance of Box Girder. Bird droppings. This should be removed.</td>
</tr>
</table>

Tuesday January 26th, 2016

The Study Team visited the Bridge Site at 10 AM.

1. East side of the bridge and north lanes. Looking towards West on Overtaking Lane. Line repairs of pavements are visible.

2. Driving Lane and 5 lines of pavement repair are visible. These lines correspond to the center of the U-ribs or the center of two adjacent U-ribs.

3. In this area, a repair line near the right white line, which is at the center of R4, is visible. But over this line, tires do not run so often and the reason of the crack formation is unclear.

4. On the south lane, the pavement crack over R4 U-rib is not formed.

5. Near the bridge center, a crack line over R4 is not formed.

6. Near the tower, pavement materials were removed and the starving horse is visible. A temporary hand hole is between R4 and R5.

7. The welding line of R4 U-rib below the steel deck, which is 64cm apart from the curb is visible on the left of the brown shoes.

8. Corroded area near the west tower. This may be worst corroded.

9. Corrosion near the west tower and on the North Lane.

10. The corroded areas are on both sides which are below the cracked pavement areas. The center area is healthier.

As shown in Fig.1 & 2, pavement cracks roughly correspond to the tire passing lines.

Also the pavement cracks correspond to the positions of the center of U-ribs, or the center of two adjacent U-ribs. This means that the pavement cracks occur over the plates under which no reinforcing ribs exist. This can be seen from the report of 2012, too.

The cracks may have been caused by the deformation of the steel deck plates over an empty space of the U-rib or an empty space between two adjacent U-ribs.

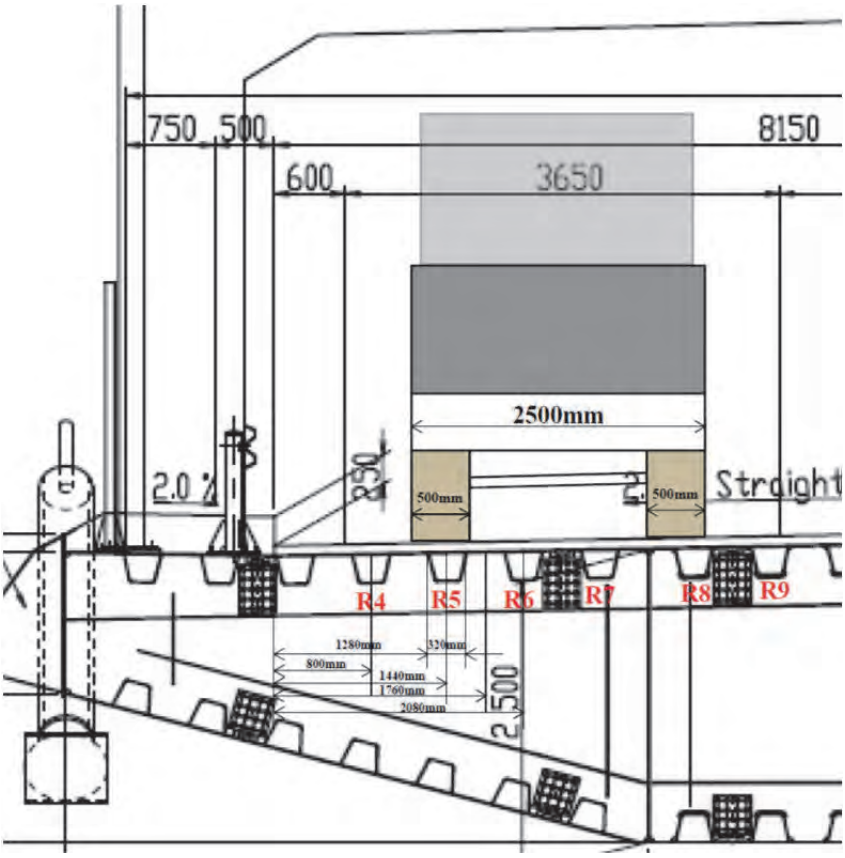


Fig.1 Distance from Curb to Center of U-ribs or to Center between Two adjacent U-ribs

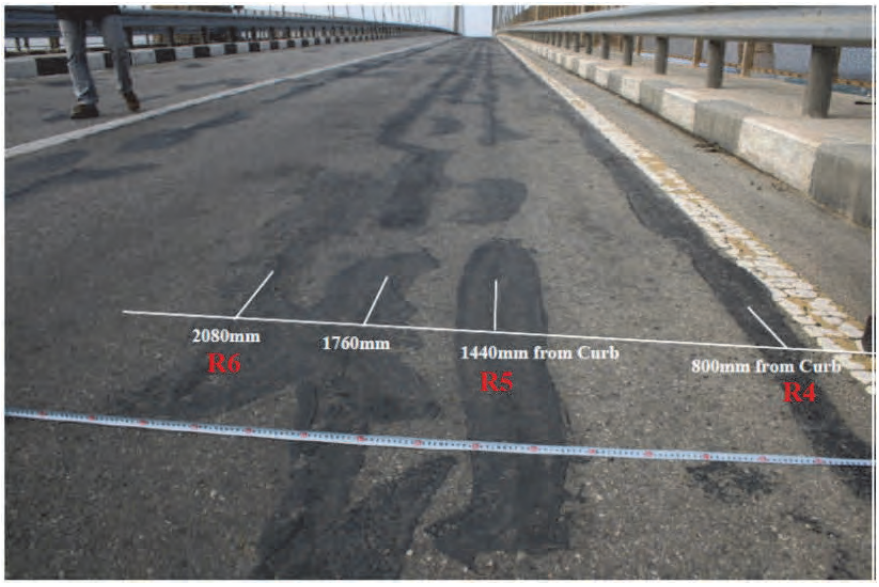


Fig.2 Pavement Crack Repair Lines and positions of U-ribs

Wednesday January 27th, 2016

The Study Team visited the Bridge Site at 10 AM and inspected the inside of the box girder, especially R8 U-rib areas. The inspected area was the west side span and the welding beads of north and south R8 U-rib were inspected. No paint cracks were found.

Welding bead of South Side R8 U-rib	Welding bead of North Side R8 U-rib
	
1. R8 and D2 diaphragm, East face.	1. R8 and D2 diaphragm, East face.
	
2. R8 and D10 diaphragm, East face.	2. R8 and D10 diaphragm, East face.

Thursday January 28th, 2016

The Study Team visited the Bridge with the Consultant, Dr. Omar, at 11 AM and inspected the pavement condition.

1. Cracks on driving lane of East Bound Lane (South Lane) on West side span. Distance from center of South Lane is measured.

2. Cracks on driving lane of East Bound Lane (South Lane) on West side span. Distance from Curb is measured.

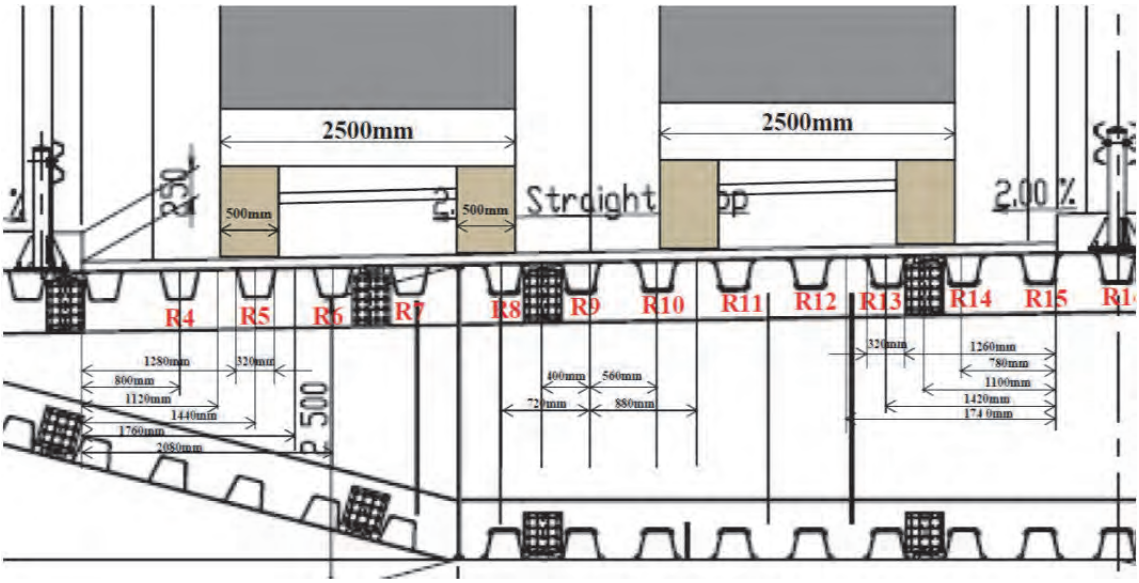


Fig.1 Cross Section of Deck Plate

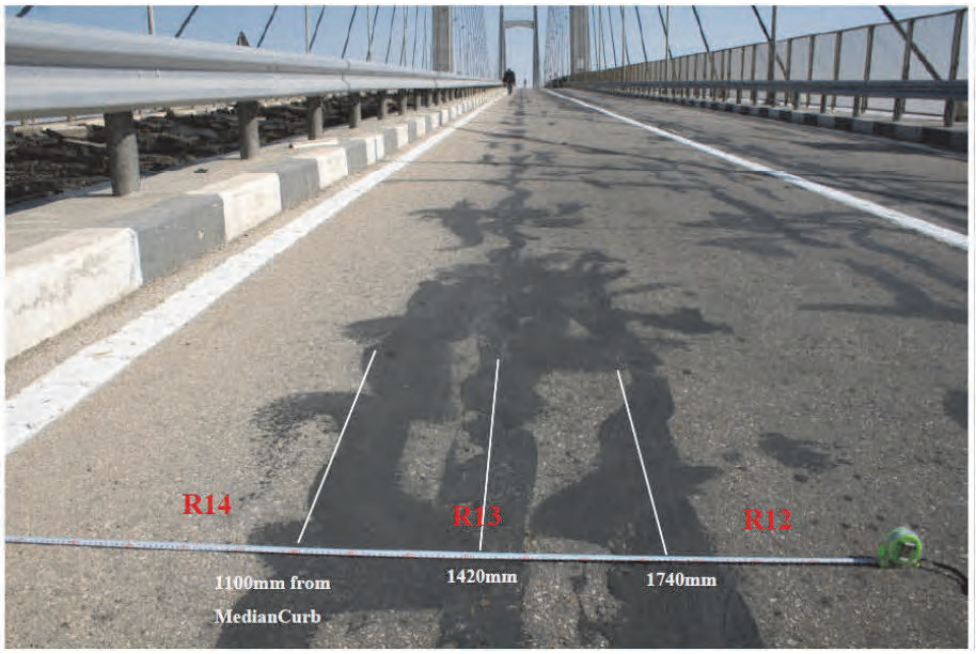


Fig.2　South Lane, Line cracks and U-rib Positions, Overtaking lane near Center

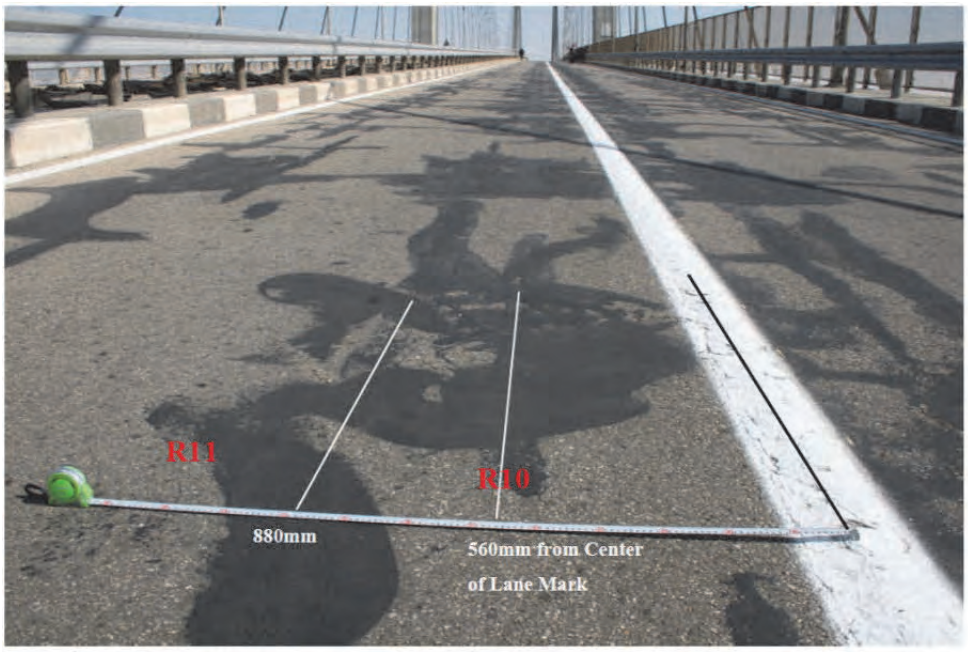


Fig.3　South Lane, Line cracks and U-rib Positions, Overtaking lane outside

3. Removed pavement of North Lane, west side span. Back side of pavement. This black color indicates healthy adhesion to steel deck.

4. Back side of removed pavement. This red color shows steel deck corrosion.

5. North side curb and some rust of steel deck plate is seen.

6. Steel deck near center median. No rust is seen here.

Thursday February 4th, 2016

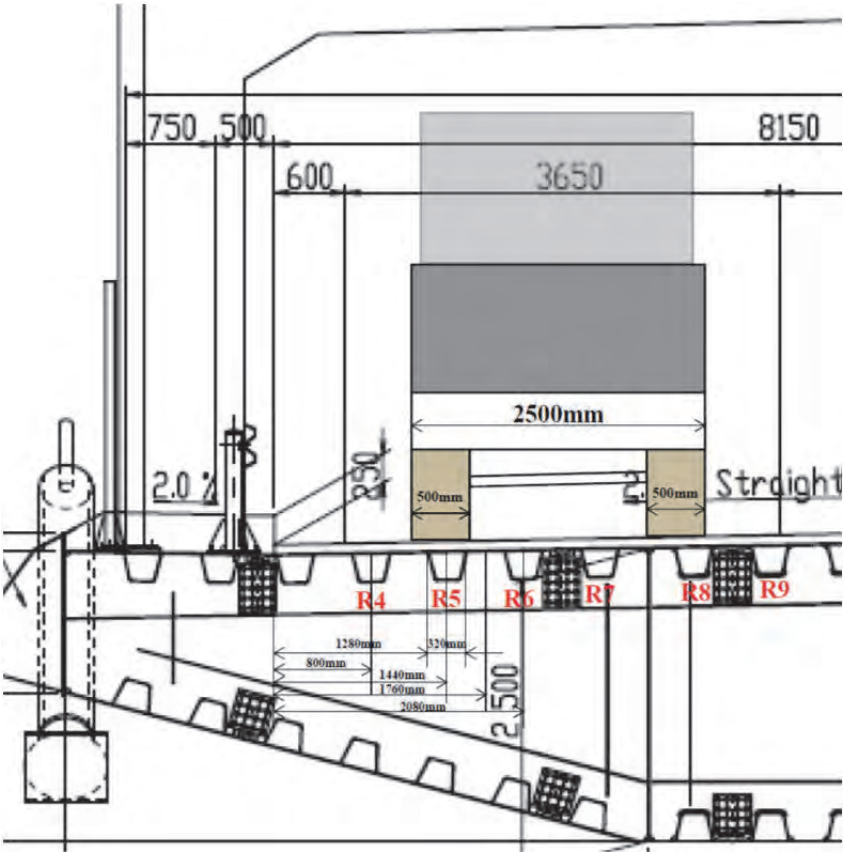


Fig.1 Bridge Deck and Tire Positions

On 27th January, R8 U-ribs of North and South Lane of side span were inspected. Fortunately no fatigue cracks were found. As the continuation of R8 U-rib checking, the half of the center span was inspected by JICA Study Team.

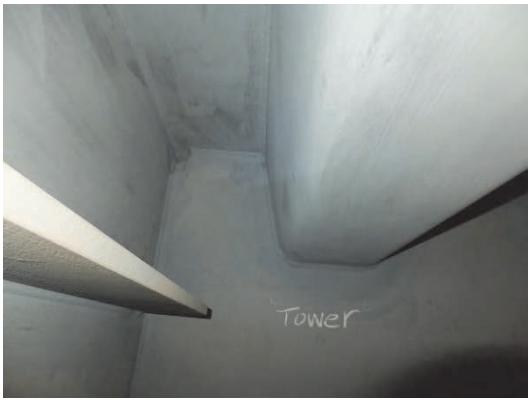
As a result, no paint cracks nor fatigue cracks were found.

The Study Team visited the Bridge Site at 10 AM and inspected the inside of the box girder, especially R8 U-rib areas. The inspected area is the west side of the center span, i.e. from D30 Diaphragm near the west tower to D64 Diaphragm at the center. Only the south side R8 U-ribs are shown in the table below.

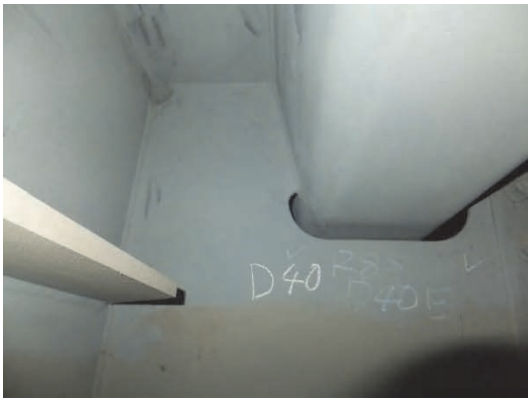
Near D58 Diaphragm and South Lane, there are large cracks of pavement as shown in the photo. The U-ribs below these cracks are also inspected closely.

1. This is the same photo of 28th Day Report. Large cracks at center of center span on South Lane near 3rd cable from the longest west side cable. It seems the pavement is flowing. The reason is unclear. 3rd cable is fixed near D58 Diaphragm. The inside around D58 was examined.

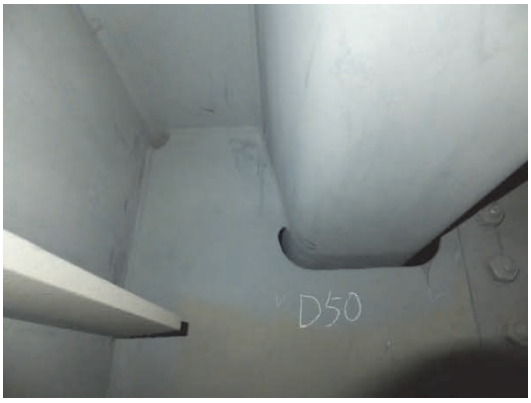
2. This is the same photo as Photo 1 from 28th Day Report. The same large cracks as Photo 1.



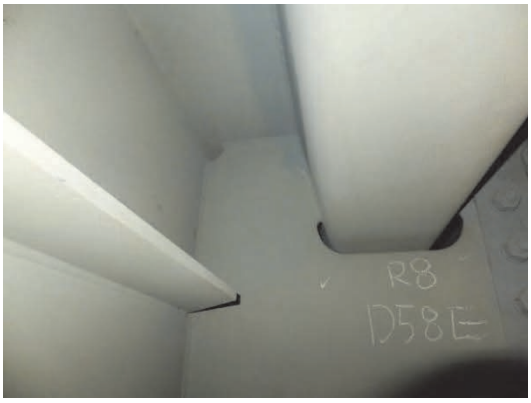
3. Only south side R8 U-rib is shown. D30, East face at Tower. No paint cracks were found.



4. D40 diaphragm, east face. No cracks.



5. D50 diaphragm, east face. No cracks.



6. D58 diaphragm, east face. No cracks. Above this area, pavement cracks exist.

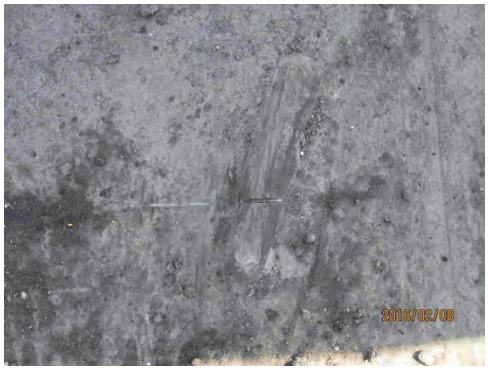
Monday February 8th, 2016

Main work is the removal of pavement on east side.

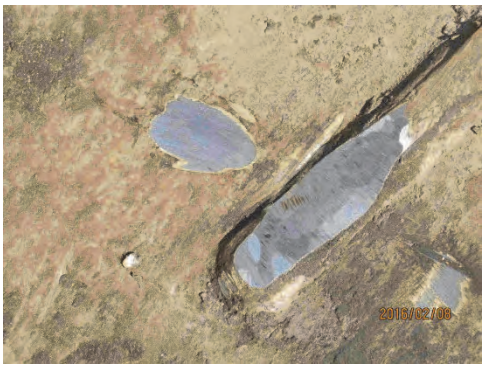
Samco smoothed the over cut area.

1. Removal of pavement on east side.

2. Taking away removed asphalt.



3. Over cut of steel deck



4. Samco smoothed the over cut area.

Wednesday February 17th, 2016

The Study Team visited and inspected the surface of East side after removal of the pavement.

A line of rust can indicate the existence of penetrated fatigue crack from inside of the deck plate. So the checking of a line of rust is very important.　Lines of rust were not found.

1. Surface after removal of pavement.

2. Corrosion of the surface East side (North lane)

APPENDIX 2 THICKNESS MEASUREMENT OF STEEL DECK PLATE

Wednesday February 3rd, 2016

The Study Team checked the orthtropic steel deck plate thickness. The area of thickness check is on the North Lane and Western half of the bridge deck. The inspected area is shown on the attached sheet. The result of measurement is shown in the table below. The healthy areas show the original plate thickness of 12mm or the value close to 12mm. But the areas with some corrosions, the surface is not flat and the measurement was unstable. The values more than 12mm may be wrong or incorrect. The worst place is Extra1, whose thickness is shown in red. The place was found after the measurement of all points and was measured to confirm the corrosion. As the surface was not flat, the surface was ground slightly to have a small flat area for the measurement. The thickness was 11.21mm. The measument D6 shown in blue is 11.66mm. This value was 11.97mm. After the measurement of Extra1, D6 was measured again after grinding the surface slightly to have a small flat area. Then the measured value reduced from 11.97mm to 11.66mm. From this result, the corroded areas which show more than 12mm may have the thickness of about the same value as 11.66mm. As it was tried to measure more corroded areas, the measured results may be worse than the real average thickness. From the total area inspection, corrosions are found more on both lane ends and the center of the North lane. Other areas are comparatively healthy.

Table 1 Measured Plate Thickness (mm)

	North Lane (West Bound, Sinai to Ismailia)				
Distance From Bridge end	Point	Center of Bridge			Bridge Edge
		A	B	C	D
15m	1	11.83	11.70	11.70	11.97
30m	2	11.67	11.97	11.85	11.81
55m	3	11.90	12.01	11.76	12.09
58m	Extra1				11.21
80m	4	12.03	11.91	12.17	12.04
115m	5	11.94	11.97	12.06	12.09
150m	6	11.94	12.09	12.01	11.66
163m	Tower				
200m	7	12.10	12.07	11.95	12.01
250m	8	11.88	12.07	11.88	12.01
290m	Extra2	11.85			
300m	9	11.91	12.00	12.15	12.12
350m	10				
365m	Center				

1. Measured area. North Lane and Western Half of the bridge.

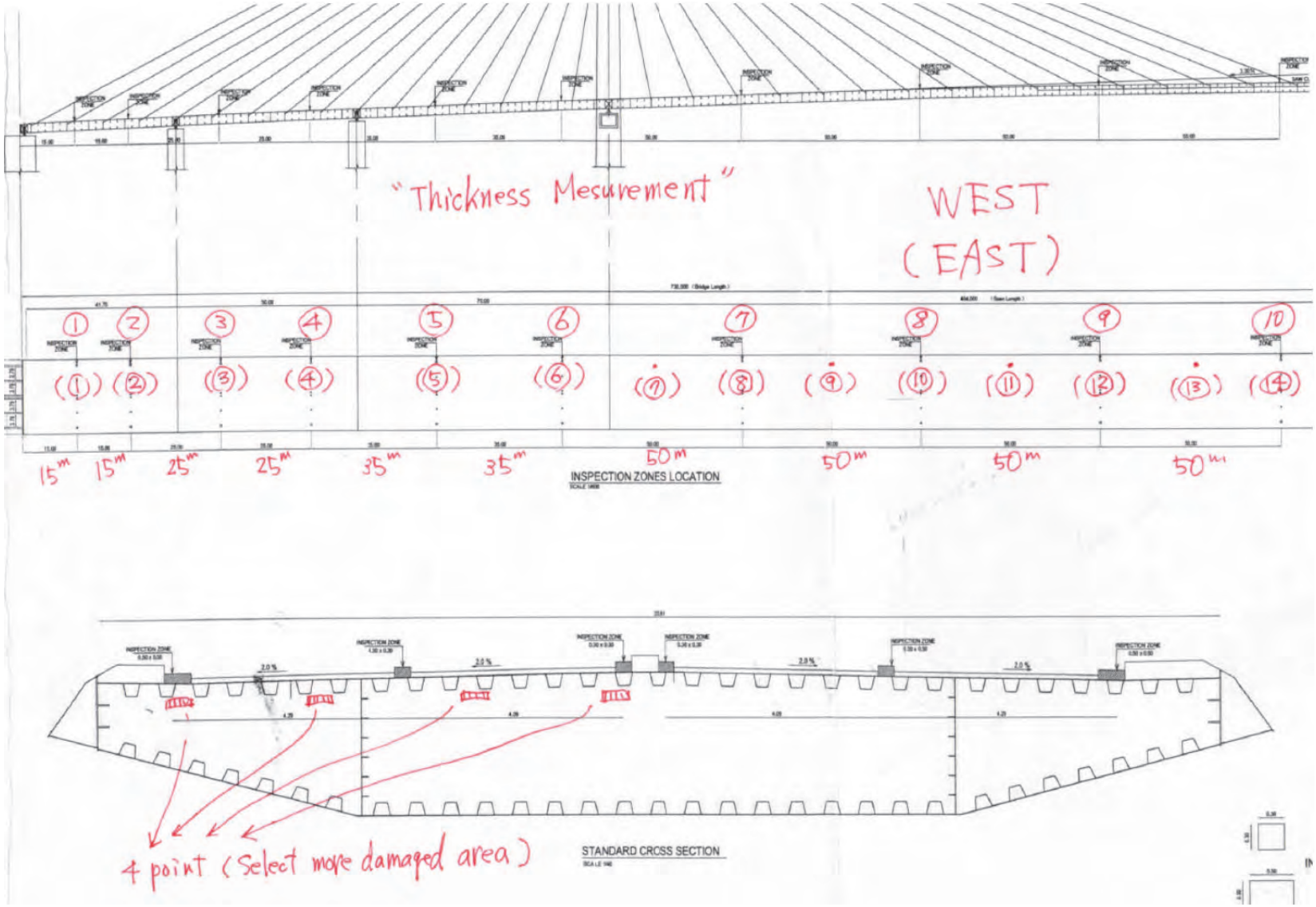
2. White area is healthier. Rust exists mainly at both ends and at the center.

3. A1 measurement

4. C1 measurement

5. D1 measurement

6. A2 measurement


"Thickness Mesurement"
WEST
(EAST)
INSPECTION ZONES LOCATION
15m 15m 25m 25m 35m 35m 50m 50m 50m 50m
4 point (Select more damaged area)
STANDARD CROSS SECTION

Wednesday February 18th, 2016

The area of thickness check is on the North Lane and Eastern half of the bridge deck February 18.

The result of measurement is shown in the table below.

Table 2, Measured Plate Thickness of east side (mm)

	North Lane (West Bound, Sinai to Ismailia)				
Distance From Bridge Center	Point	Center of Bridge			Bridge Edge
		A	B	C	D
-30m	1	12.05	11.81	11.77	12.01
-15m	2	11.97	11.84	11.97	11.92
10m	3	12.01	11.97	12.02	12.07
35m	4	11.87	11.89	11.93	11.78
60m	5	11.87	11.98	11.86	11.98
85m	6	11.96	11.95	11.95	12.01
110m	7	11.74	11.22	12.00	11.81
135m	8	11.63	11.75	11.92	11.82
160m	9	11.87	11.75	11.78	11.91
185m	10	12.01	11.88	11.99	11.98
210m	11	11.85	11.84	11.81	11.95
235m	12	11.81	11.69	11.78	11.64
260m	13	11.91	12.05	11.65	11.87
285m	14	11.68	11.51	11.60	11.78
310m	15	11.92	11.91	12.01	11.81
335m	16	11.87	11.99	11.60	11.81
360m	17	11.66	11.34	11.16	11.65
				Average	11.83

	Re-measured after Grinding

1. Measurement of Steel Deck plate

2. Measurement of Steel Deck plate

APPENDIX 3 MAASARA BRIDGE

On 6th February, the Study Team visited the Maasara Bridge in Cairo City, at 11 AM and inspected the pavement and the orthotropic steel deck. The Maasara Bridge was constructed in 1988 when the subway was constructed by French Team. The Maasara Bridge which overpasses the subway was also designed by the French Team. The fabrication was also supervised the French team according to Dr. Meguid of ACE consultant. The pavement of the Maasara Bridge was a different one but it was repaved during January 1st to March 22nd, 1994 by the same specification proposed by the ACE consultant for the SUEZ Bridge. Since 1994, the pavement of the Maasara Bridge has shown the good results. The present condition of the pavement was inspected at the site.

1. The Maasara Bridge over Subway. On the right is the South Lane.

2. The Maasara Bridge, this bridge was constructed hastily, that was the reason why the orthotropic steel deck was adopted. Subway tracks can be seen on the left, North side.

3. The traffic volume is not large but sometimes lager trucks pass.

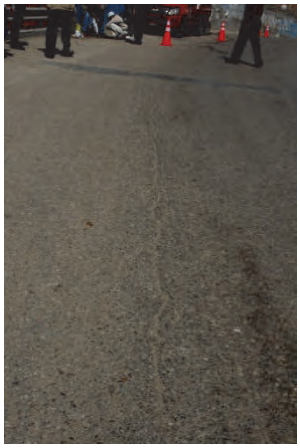
4. Passing truck

5. Panels of orthotropic steel deck were fabricated at the shops and transported to the site and assembled. One panel is about 8m long, if lateral rib spacing is 2m, and consists of 6 U-ribs. The U-rib directly above the longitudinal beam is not a U-rib but it consists of two inclined plates. The south side lane consists of two panels and the north side lane also consists of two panels.

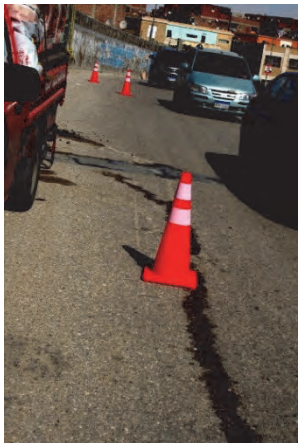
6. The open trapezoidal shape directly above the longitudinal beam shows the U-rib which consists of two inclined steel plates.

7. Two panels are connected at the center of south lane.

8. Connection of adjacent panel. U-rib details are quite fine.



9. Cracks on the pavement. These cracks seem to correspond to the position of two panel connection, because two panels can move independently to some extent.

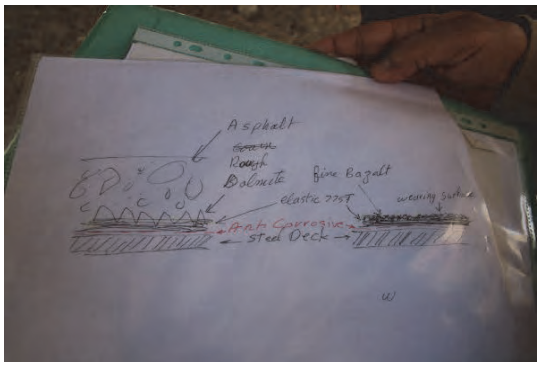


10. Cracks on the pavement. These cracks seem to correspond to the position of two panel connection.

11. U-ribs and adjacent U-ribs directly above the longitudinal beam and consisting of two inclined plates.

12. Inclined plate above the longitudinal beam. The structure is well-designed. No sign of fatigue cracks were found.

13. On the bridge deck, the pavement was investigated.



14. Pavement structure. Tar Epoxy and dolomite. Above it, the asphalt pavement was placed.

15. Condition of pavement was quite good and no rust was observed on the deck surface. The yellow color shows the Zinc Chromate. Hexavalent(+6) Chrome is toxic but Trivalent(+3) Chrome is not.

16. Size of the hole on the deck

17. Drilled hole for core sampling.

18. Drilled core. The pavement is healthy.

19. In 1994, both sides of the bridge was painted by Zinc Rich Paint. But Subway Company refused to paint the center of the bridge. It is said that the weathering steel was adopted for this bridge. Then it was not needed to paint.

20. Space of longitudinal web is large.

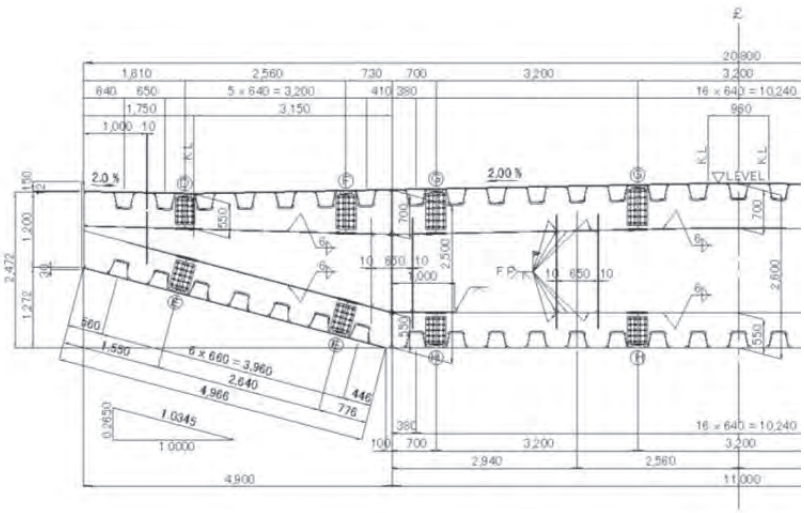


Fig.1 Cross section of Suez Bridge

The structure of the orthotropic steel deck panel adopted for the Maasara Bridge resembles the structure of the orthotropic steel deck adopted for the Suez Bridge.

But the longitudinal stiffness of the Maasara Bridge seems to be higher than that of the Suez Bridge, because the space of two U-ribs are supported by two longitudinal beams. (Photo 5) But the space of the longitudinal web of the Suez Bridge is much longer. (Photo 20)

But these two orthotropic steel decks are supported by about 2m interval lateral beams, which are common for both two bridges.

The local area stiffness of the deck plate of these two bridges is similar. But the longitudinal stiffness of two bridges is different. Therefore it is difficult to conclude that this pavement is applicable to the Suez Bridge, as we do not have the experience of the application of this kind of pavement on the long span orthotropic steel deck bridges in Japan.

But at the same time, there is a possibility that the application of this pavement to the Suez Bridge can be successful.

Our conclusion is that we cannot guarantee the success of the application of this pavement to the Suez Bridge but at the same time we do not oppose your application of this pavement to the Suez Bridge at your own responsibility.

APPENDIX 4　PAVEMENT WORKS

4.1　Test working of sand blasting and painting of primer

Test working of sand blasting and painting of primer were implemented at west end point of bridge on February 11th.

(1)　Sand blasting

The surface after sand blasting is almost good. But in some area the corrosion is still remain, so Mr.Ahmed(GARBLT) ask SAMCO to do sand blasting perfectly in actual stage. The sand near the bridge was not used because that includes salt.

(2)　Painting of primer

Zinc Chromate(Polymar 730CH) is used as primer.

Painting by spray and by roller were compared, then roller method was selected because of workability.　Technical data of primer is shown Fig.2.4.1.

1. Testing work of sand blasting

2. Before sand blasting

3. After sand blasting

4. Painting by spray

	
5. Painting by roller	6. Measurement of thickness; A little too thick, so it will be reduced more totargeted 0.05mm on actual stage.

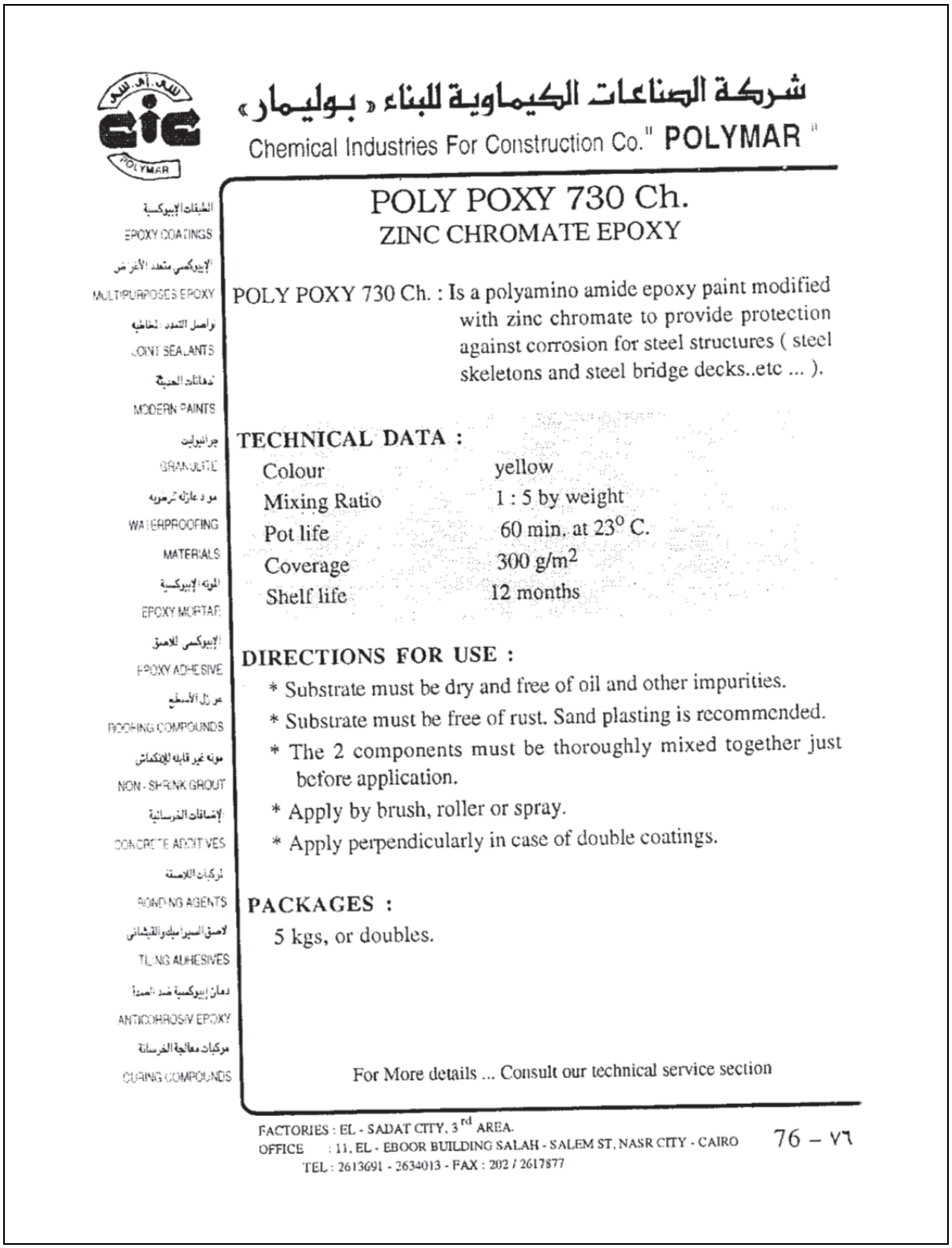


Fig.2.4.1 Technical date of primer

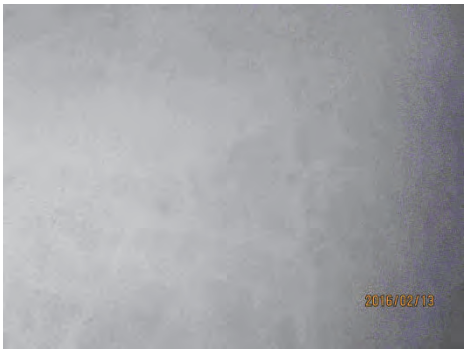
4.2 Sand blasting and painting of primer

Sand blasting and painting of primer started on February 13th from center of bridge to west side.

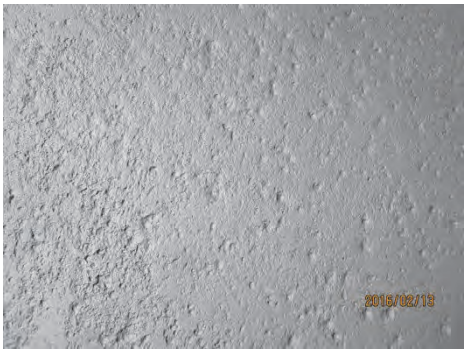
Sand blasting takes so long, so that Mr.Ahmed(GARBLT) and ACE consultant ask SAMCO to increase sand blast machines and workers.

1. Work of sand blasting

2. Sand for sand blasting



3. After sand blasting



4. After sand blasting

5. After sand blasting

6. Painting of primer(Zinc Chromate)

	
7. After painting of primer	8. After painting of primer

APPENDIX 5 TRAINING SEMINAR

JICA team explained the maintenance management plan 7th September.

The contents are as follows (See Appendix 5).

1. Pavement
2. The Repair Plan for the Steel Deck plate
3. The Reinforcement method of the Steel Deck plate

Follow-up Cooperation Study on the Bridge Design(Counterpart Training for the Suez Canal Bridge Project)

Training Seminar

September, 2016

Oriental Consultants Global Co., Ltd.
CHODAI Co., Ltd.

1

Contents

1. Pavement
2. The Repair Plan for the Steel Deck plate
3. The Reinforcement method of Steel Deck plate

2

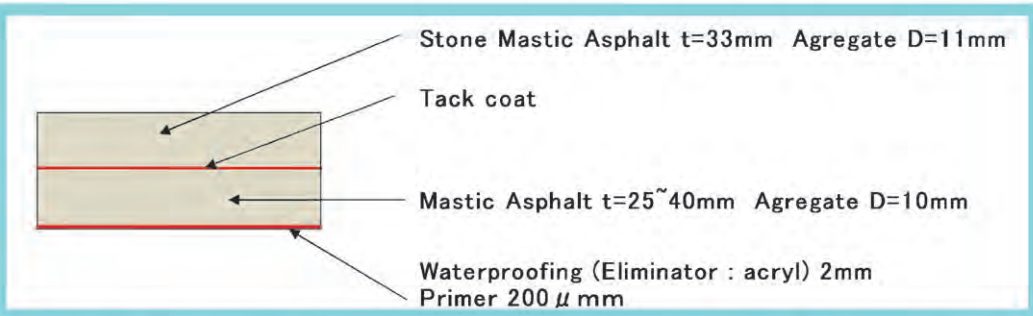
1 Pavement

The pavement work (Type recommended by GARBLT) was finished in North Side. The condition of pavement is looks very well. But investigation for the pavement must be implemented constantly. If the serious damage is happened again, the alternative method must be studied.

JICA study team recommend Guss Asphalt regarding to the experience in Japan. Meanwhile, in Europe "Mastic Asphalt" is used popularly for steel deck plate. The quality "Mastic Asphalt" is supposed to be same as Guss Asphalt. "Mastic Asphalt" is mentioned in BS 1447.

"Mastic Asphalt" will be used for Izumit bridge in Turkey. Formation of this bridge is as follows.

3

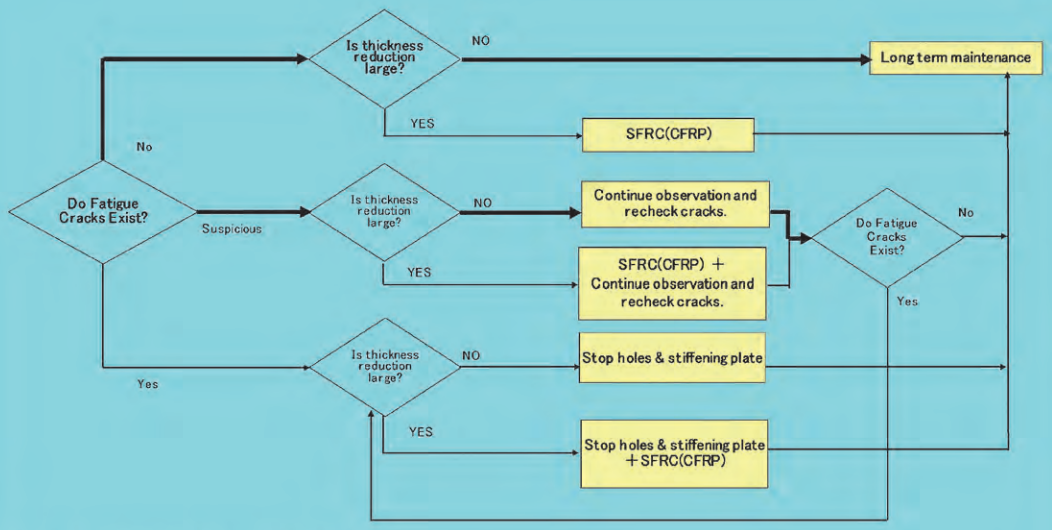


2 The Repair Plan for the Steel Deck plate

The study team will recommend the Repair method of Steel Deck, by taking into account the following items. (Refer to the flow chart (next page))

- Damage condition
- The evaluation of safety of Steel Deck according to the reduction of the plate thickness
- Existence of fatigue cracks
- The construction constraints in Egypt

4



Note; This flow assumes the good result of pavement application. If the result is not good, the investigation of suitable pavement methods is needed.

Selection of Reinforcing Method of Orthtropic Steel Deck

5

3 The Reinforcement method of Steel Deck plate

3-1 General

The reinforcement method shall be adopted following cases.

Case A : Thickness reduction is large (Effect the soundness of Steel Deck plate)

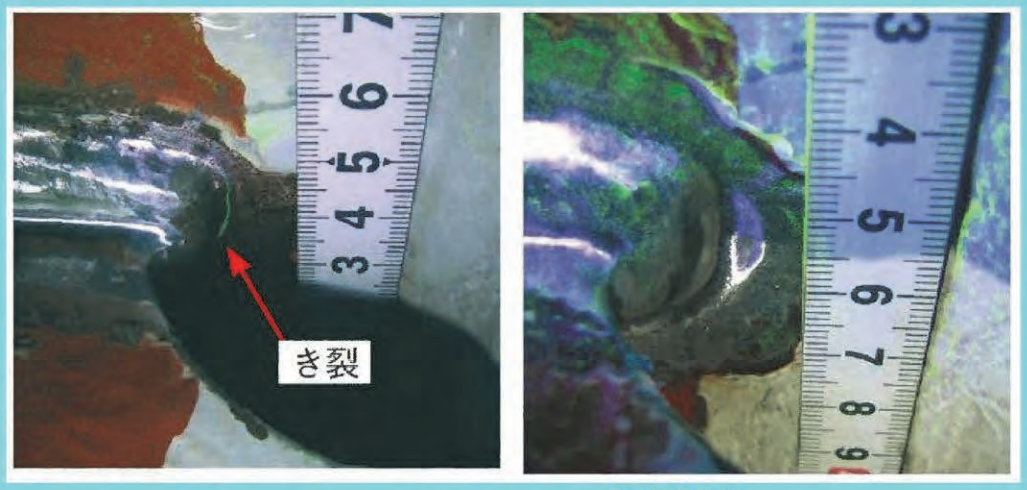
Case B : Fatigue cracks happened

The reinforcement method will be mentioned in 3-2,3-3,3-4.

In case of "Case B", before reinforcement of whole Steel Deck plate , the parts where fatigue cracks happened must be repaired by the method mentioned next page.

6

Repair of Crack



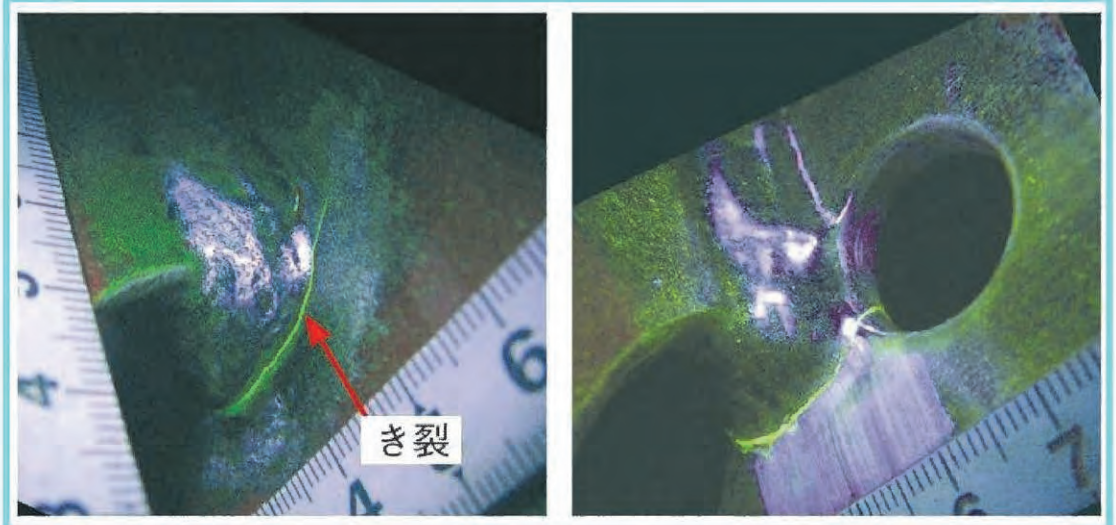
Removal of cracks by grinding.

Source: Kawada

http://www.kawada.co.jp/technology/gihou/pdf/vol28/28_gijutu_03.pdf#search='%E9%8B%BC%E5%BA%8A%E7%89%88%E3%81%AE%E4%BF%AE%E7%90%86%E5%B7%A5%E4%BA%8B'

7

Repair of Crack



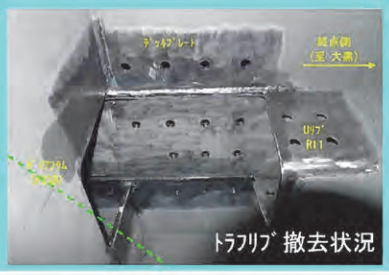
Application of stop holes.

Source: Kawada

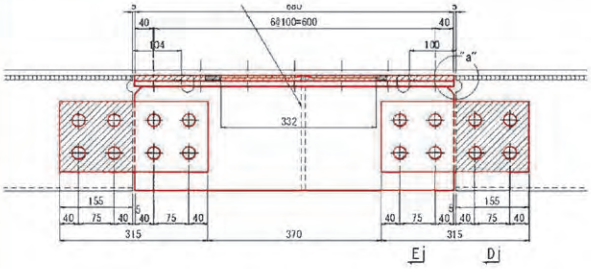
http://www.kawada.co.jp/technology/gihou/pdf/vol28/28_gijutu_03.pdf#search='%E9%8B%BC%E5%BA%8A%E7%89%88%E3%81%AE%E4%BF%AE%E7%90%86%E5%B7%A5%E4%BA%8B'

8

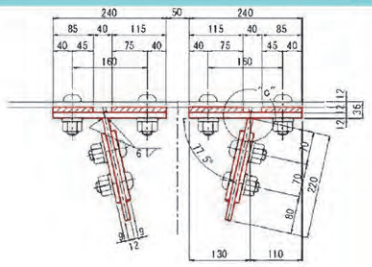
Repair of Crack (Removal and reinforcement of U-Rib)



Changing of damaged U shape rib



トラフリブ側面図

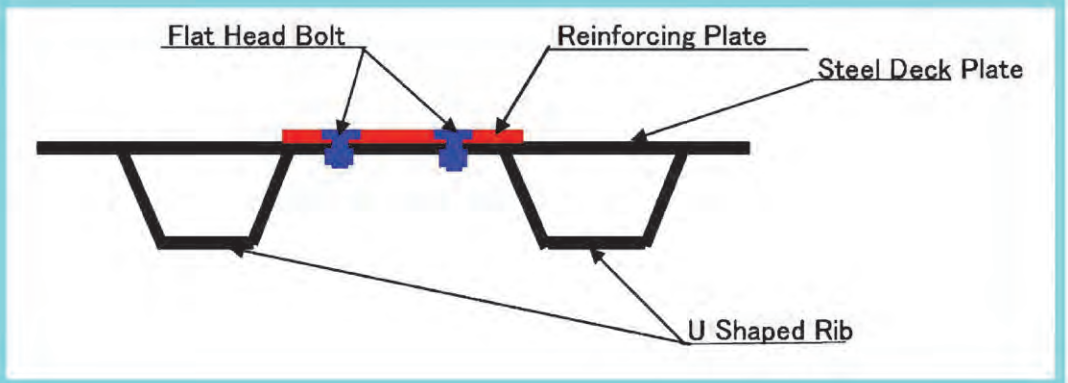


トラフリブ断面図

9

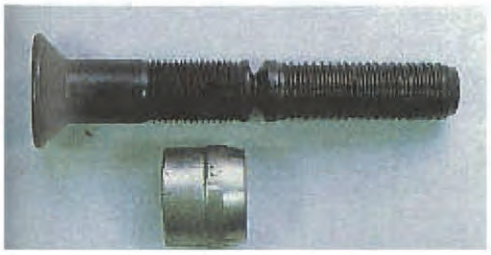
Source: Metropolitan Expressway Company

Repair of Crack (Cracks of Deck Plate)



10

Repair of Crack (Application of Reinforcing Plate)

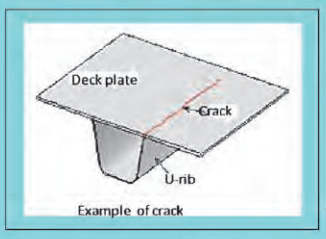


11

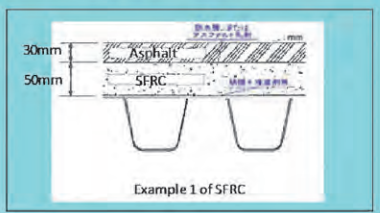
3-2 SFRC

3-2-1 SFRC

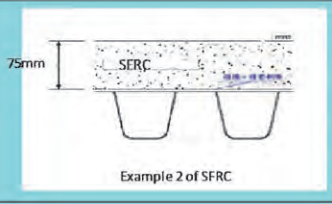
SFRC(Steel Fiber Reinforced Concrete) was developed in Japan to prevent fatigue cracks and to reduce the deflection. The highly durable epoxy resin adhesive between the steel deck plate and the steel fiber reinforced concrete achieves the unity of the deck plate and the concrete. SFRC can be applied with the conventional equipment.



Example of crack



Example 1 of SFRC



Example 2 of SFRC

12

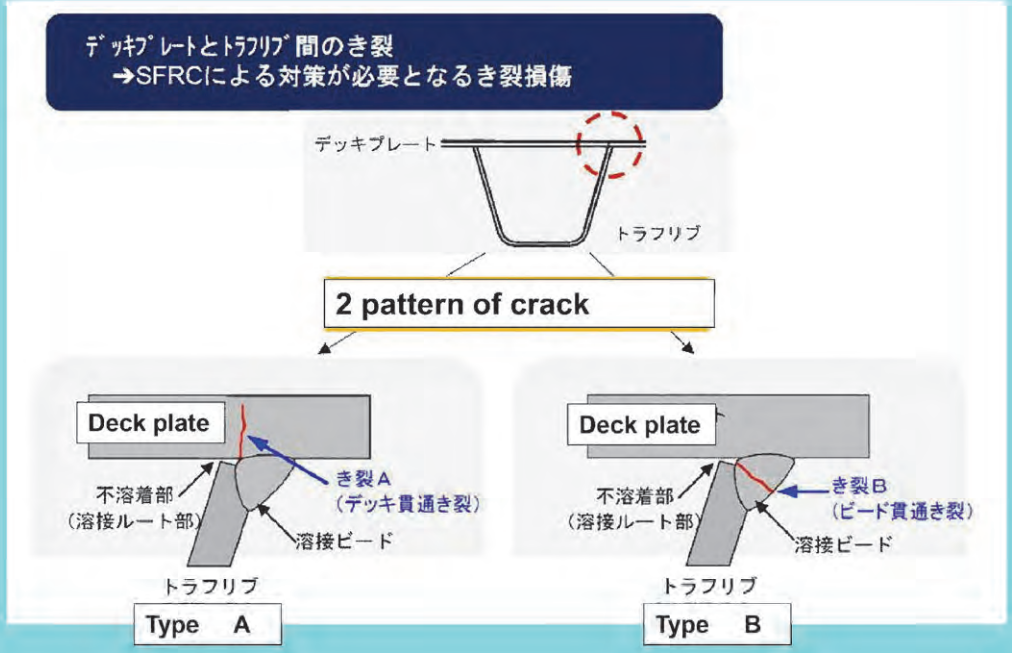
3-2-2 Example (Bay Bridge in Japan)

On first stage (Under-deck for National road 357), stud bolts were used for connecting between Steel Deck plate and SFRC.

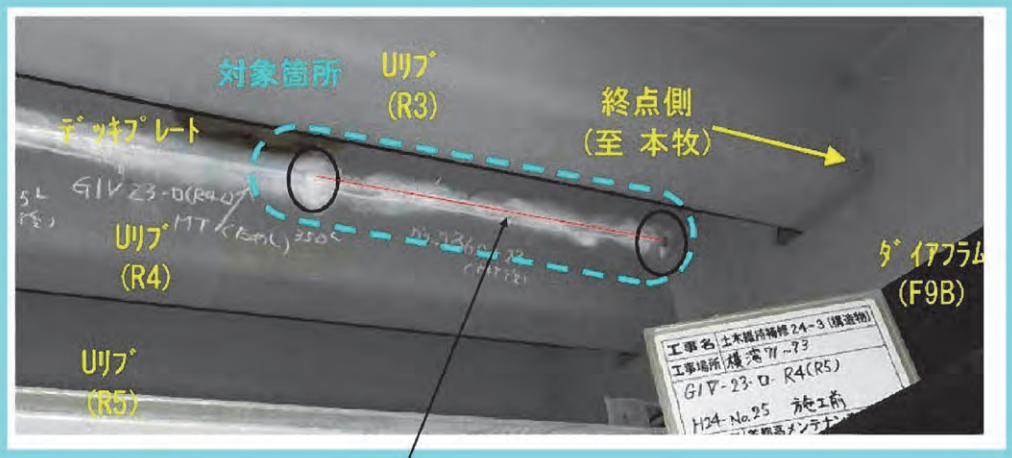
But cracks happened around the stud bolts, so stud bolts are not used on second stage(Upper-deck fro Metropolitan expressway).

The repairing works of Bay Bridge is mentioned next page.

13

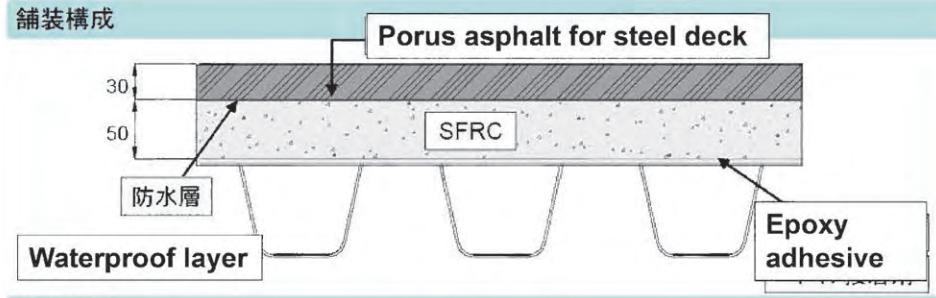


14



15

舗装構成



施工状況

16

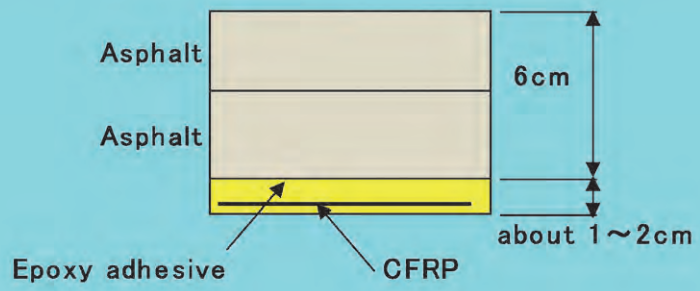
3-3 CFRP

CFRP is popularly used for repairing and reinforcing of the RC slab, RC&PC girder and Steel girder internationally. In Japan CFRP is also used for reinforcing the surface of bridge.

CFRP only resists to tension side and no experience for Steel Deck.

But Steel Deck is continuous, so resisting at tension side means the reduction of deformation .

In case of adopting to Steel Deck, CFRP must be studied more.



17

In Mongolia, CFRP was adopted in JICA project in 2015. CFRP specialists supervised how to utilize CFRP, therefore the contractor in Mongolia constructed appropriately.

Undercoating of Epoxy adhesive

Setting of CF (Carbon-fiber)

Final coating of Epoxy adhesive

18

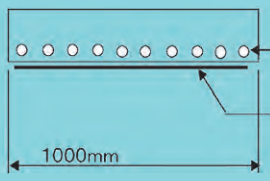
CFRP is used for the repair and strengthening for Re-bar of concrete structure.

In Japan high modulus CFRP is popular for the repair and strengthening of RC.

The following shows the merit of high modulus CFRP.

In this case, if normal modulus CFRP is used, 2 sheets are required. But in case of high modulus CFRP, it is enough to use only 1 sheet.

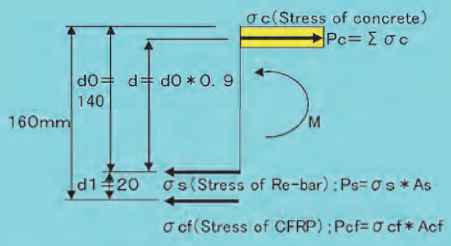
In case of adopting to Steel Deck, CFRP must be studied more.



Re-bar φ10ctc 100mm As=785mm^2

CFRP t=0.143mm*1sheet High Modulus Ecf= 640000N/mm^2

or CFRP t=0.167mm*2sheet Normal Modulus Ecf= 230000N/mm^2



$$\sigma s = M/(As + (Ecf/Es) * Acf)/(d + d1/2)$$

(Stress by Live-Load)

High Modulus

$$\sigma s = \frac{25.48 * 10^6}{(785 + (640000/200000) * 143) * (140 * 0.9 + 20/2)}$$

$$= \frac{25.48 * 10^6}{1243 * 136}$$

$$= 151 N/mm^2$$

Normal Modulus

$$\sigma s = \frac{25.48 * 10^6}{(785 + (230000/200000) * 334) * (140 * 0.9 + 20/2)}$$

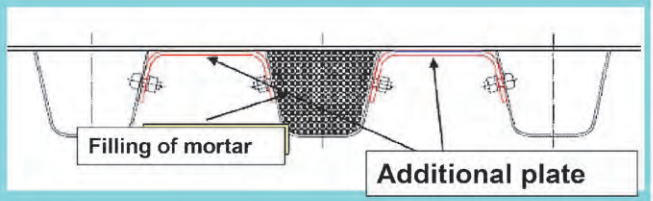
$$= \frac{25.48 * 10^6}{1169 * 136}$$

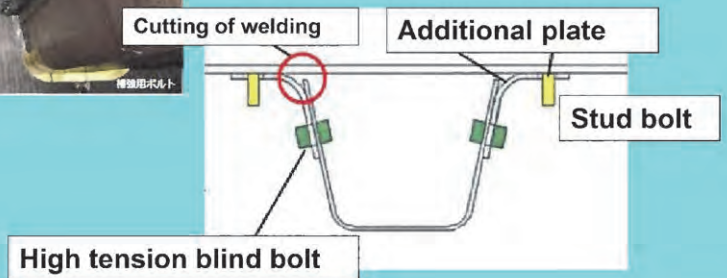
$$= 160 N/mm^2$$

3-4 Reinforcement by steel plate from under -side

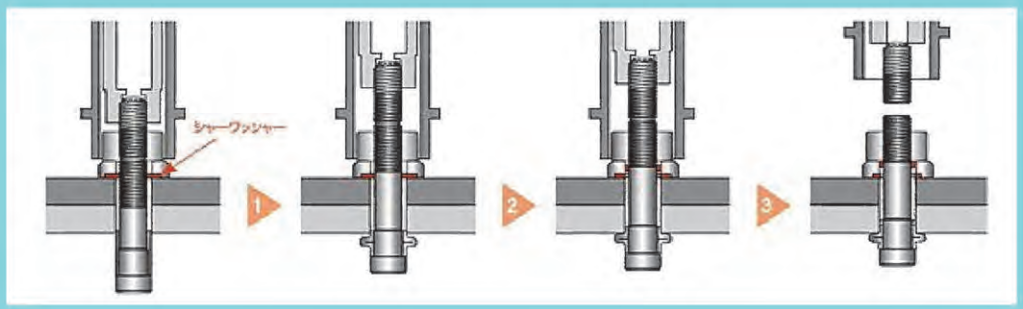
This method is to reinforce the steel deck plate only from under-side, so the traffic restriction is not needed.

This method is just on studying in Japan.





21



High tension blind bolt

22

APPENDIX 6 OTHERS

6.1 Checking of water level

Sunday January 31st, 2016

The Study Team visited the Bridge at 12 noon, delayed due to the police traffic accident.

In 2012 study, water measuring points were placed on the road edges as shown in Fig.1. The condition and the water level of these points were investigated.

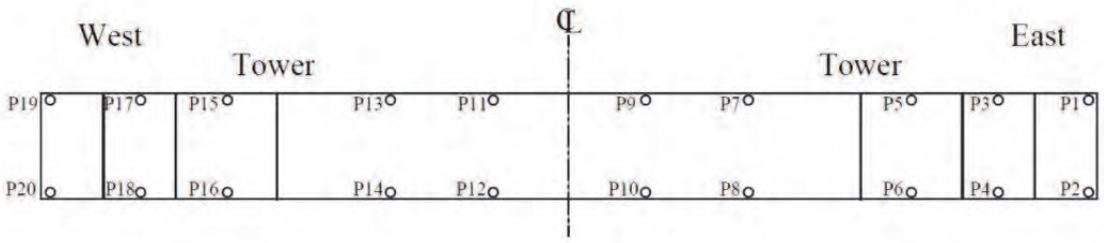
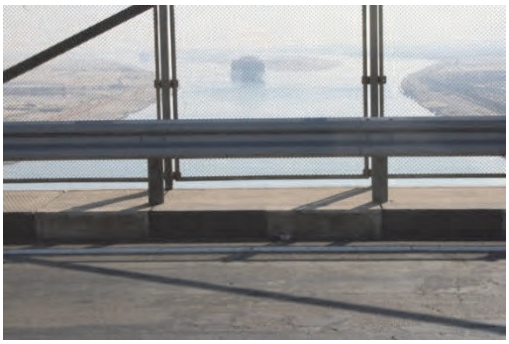


Fig.1 Points of water accumulation measurement

1. P11, Some water is observed and the bottom surface is swollen.

2. P11, bottom surface is broken by hand and rusty deck plate appeared.

3. P11, Bottom rubber plate



4. P12, a cap remains.

5. P12, higher water level than others.

6. P13, Removed pavement and a cap on pavement.

6.2 Surface of Steel Box girder

Tuesday February 2nd, 2016

The Study Team inspected the bridge girder from the inspection vehicle. Though the bridge girder is coated with very fine sands, the condition is good, except for one place of the fairing.

1. Spot rust

2. The same kind of rust as Photo 24. The all surfaces are covered by very fine sand, which may include salt particles.

3. Some rust near pipe fixing structure.

4. Some rust near site welding. Bottom plate is also site welded.

5. Some rust.

6. Sand covered bottom plate

7. Site welded fairing part is severely corroded.

8. Corrosion. The fairing is not a structural member but it is better to remove the rust and repaint immediately.

9. Corrosion

10. Severe corrosion

The condition of the bridge deck is good partly because of the scarce rain, the good paint, etc. But one severe corrosion was found. It is on the fairing. The fairing is not a structural member so that the bridge will not collapse even if a small part of the fairing disappeared. But it is strongly recommended to remove the rust and repaint the surface immediately. Although it seems that the engineers do not inspect the bridge so often, they know the places of rust very well.

After the transfer of the bridge from Japan to Egyptian side, the maintenance is the responsibility of the Egyptian side.

6.3 Data of the pavement

National Research Centre (NRC)

Paint, Plastic & Rubber Unit

Report

About the Epoxy Painting Sample

Brought from the Specialized Company for Buildings' Chemicals (ChemBuild)

ChemBuild brought to NRC a sample from the epoxy paint (Poly Poxy T775) by a letter on 20/1/2015 to be tested according to the attached technical specification with the sample, and here are the results:

First: General description for the sample:

- The sample was brought in two metallic packages weighting: first package (Compound A) is weighing 2.0 Kg and second package (Compound B) is weighing 2.25 Kg. no information was written except a white card mentioning the product code (Poly Poxy 775T) and the producing company (Industrial Products for Building) and no other information or signatures or stamps or product number or production date or workability number.
- The sample's color after mixing is black with base (epoxy and tar) and no color separator and no masses on the surface or inside the sample and the sample is completely mixed and free from coarse materials and the sample has homogenous texture by hand mixing and no sedimentation.
- The sample gave a coating layer half shiny free from grains, liquids, cracks and it is good adhesion to the metal.
- The sample is attached with a piece of metal (Carbon Iron) with dimension (1.0m x 60 cm) coated by epoxy and a mix of sand and bazalt and the sample is prepared in the site by the company and the consultant and it is signed by Mr. Ahmed Hosain (Arab Contractors Co.) and Mr. Mostafa Fayez from the company.

Second: Results:

The sample is mixed with ratio: 1.0 (Comp. A) : 1.3 (Comp. B)

Test	Result
1- Mixing ratio	A1:1.3B
2- Color	Black
3- Drying time at 20^0C Surface drying (hours) Solid drying (hours)	 2 24
4- Workability time period at 20^0C (hours)	4
5- Density (gm/m^3) Compound (A) Compound (B)	 1.1 1.2
6- Solid content by weight (%) Compound (A)	97
7- Evaporated content by weight (%) Compound (A)	3
8- Solid content by weight (%) Compound (B)	91
9- Evaporated content by weight (%) Compound (B)	9
10- Elasticity on 3mm bar	Passed
11- Elongation (%)	125
12- Tensile strength (Mega Pascal)	5
13- Adhesive strength on iron for a sample prepared in the lab (Mega Pascal)	3.6
14- Adhesive strength on iron for a sample prepared in the site (Mega Pascal)	3.2
15- Abrasion strength for a sample prepared in the lab (1000 cycle) H22 (gm)	0.4
16- Abrasion strength for a sample prepared in the site (1000 cycle) H22 (gm)	0.5
17- Compressive strength (kg/cm^2)	540
18- Humidity resistance (7 days)	passed
19- Gasoline (Solar) resistance	passed
20- Alkaline resistance	passed
21- Acid resistance	passed
22- Mineral oil resistance	passed
23- Heat resistance 60^0 for 72 hours	passed
24- Climatic (ambient) resistance (lab. Sample)	passed
25- Climatic (ambient) resistance (site. Sample)	passed
The sample was subjected to Ultra Violet rays with wavelength 312 Nano-meter for 100 hours and the sample passed the test successfully and no cracks or apparent changes	

Comments on the results:

The results shown are for the sample brought to the Paint, Plastic & Rubber Unit in the National Research Centre (NRC) by the client without any responsibility against the NRC and the NRC is not responsible for the delivery.

Test in charge

Dr. Samir Morsy Mohamed

Chief Researcher

Prof. Dr. Ahmed Ismail Hosain

Head of the Unit

Prof. Dr. Mahmoud Ahmed Abdel Ghaffar

Signed on: 19/3/2015

شركة الصناعات الكيماوية للبناء « بوليمار »
Chemical Industries For Construction Co." POLYMAR "

POLY POXY 730 Ch.
ZINC CHROMATE EPOXY

POLY POXY 730 Ch. : Is a polyamino amide epoxy paint modified with zinc chromate to provide protection against corrosion for steel structures (steel skeletons and steel bridge decks..etc ...).

TECHNICAL DATA :

Colour	yellow
Mixing Ratio	1 : 5 by weight
Pot life	60 min. at 23° C.
Coverage	300 g/m^2
Shelf life	12 months

DIRECTIONS FOR USE :

* Substrate must be dry and free of oil and other impurities.
* Substrate must be free of rust. Sand plasting is recommended.
* The 2 components must be thoroughly mixed together just before application.
* Apply by brush, roller or spray.
* Apply perpendicularly in case of double coatings.

PACKAGES :

5 kgs, or doubles.

For More details ... Consult our technical service section

FACTORIES : EL - SADAT CITY, 3rd AREA.
OFFICE : 11, EL - EBOOR BUILDING SALAH - SALEM ST, NASR CITY - CAIRO
TEL : 2613691 - 2634013 - FAX : 202 / 2617877

APPENDIX 7 MEETING MEMORANDUM

7.1 Kick-off meeting for The Follow-up study on Suez Canal Bridge

Date: 21st January 2016, **Time** 10:00, **Place:** GARBLT

Attendances:
From GARBLT: Eng. Hala, Eng. Ali, others
From ACE: Dr. Abdel Majeed, Dr. Hamdy, Eng. Sherif
From SAMCO: Eng. Ahmed Gad, others
From JICA: Ikegami, Mukoyama, Matsumoto, Ashraf (Interpreter. Ms. Hana)

Objectives:

- Kick off for the Follow-up study on the counterpart training for the project for construction of the Suez Canal Bridge (pavement repair and steel deck inspection).
- Presenting the Inception Report.
- Organizing the work activities among GARBLT, Consultant (ACE), Contractor (SAMCO) and the JICA Expert (JE).

Main discussion points and conclusions:

- The JE explained the presentation which summarizes the Inception Report and mainly the: objectives, the last evaluation, the evaluation of the pavement, the soundness investigations, the previous rust inspections and the fatigue tests procedures (if needed).
- The attached sheets were shared from the consultant (Dr. Hamdy) to explain the soundness of the steel deck plate, the required tests and how to evaluate the safety of the deck.
- It was highlighted by the (JE) that the visual inspection of the steel deck plate (i.e. just after the removal of the pavement) is the effective way to find the cracks of the steel deck plate surface. If the surface is blasted, it becomes quite difficult to find the cracks. It is expected that two days or three days are required normally for the visual inspection of the U-ribs directly under the truck tires of the driving lane.
- If the steel deck plate loses the surface and decreases the thickness by rust, it would be difficult to repair. But the admissible thickness reduction is quite difficult to decide. 12mm plate thickness is decided from the point of view of passing tires. 12mm plate

thickness may be redundant from the point of view of structural design to support the longitudinal live loads.

- As current activities, GARBLT/SAMCO started to break the pavement layer (not removing). The removing will be in the presences of the JE. Some parts are removed (small locations) and GARBLT found that, there is no rust in the middle of the bridge.
- It was agreed that a preliminary investigation will start next week to evaluate the situation in the site after removing of the pavement. It is expected to have another meeting to evaluate the situation after evaluating the seriousness of the surface cracks.
- The JE asked about the tests for the pavement section. The SAMCO replied that the tests are done for the base layer with two models (zinc rich and chrome rich). The JE advised not to use (chrome rich) model because Chrome is toxic. Also, the JE asked for the full pavement model. SAMCO informed that the results will be ready next week.
- The JE asked for the water proofing (insulation) test but SAMCO informed that the test was done on the painting material not on the water proofing material. A report was handed (attached).
- In discussion with the consultant (ACE), it was informed that the ACE asked GARBLT/SAMCO many times about the tests for the pavement with specific tests including the pull out test but GARBLT/SAMCO did not answer this request.
- GARBLT will inform JICA/JE about the start of work. It is expected to be by Saturday (after confirmation by Eng. Ali and consultation with GARBLT Chairman).

(END)

Follow-up Cooperation Study on the Bridge Design (Counterpart Traning for the Suez Canal Bridge Project)

Attendance list of the meeting with GARBLT & other Consultants on Jan. 21st 2016

Name	Job title / Organization
Eng. Ahmed Gad	Vice president of SAMCO
Eng. Salah Mostafa	Chemicals for Building co.
Eng. Galal Sobhy	Chemicals for Building co.
Dr. Sherif Habib	ACE Consulting
Dr. Eng. Hamdy Elshawat	ACE Consulting
Eng. Abd El-Maguid	ACE Consulting
Eng. Hala Sayed Helmy	Head of Bridge Sector / GARBLT
Eng. Aly Elsafty Abdallah	GARBLT
Eng. Osama Aly Fahmy	GARBLT
Eng. Essam Taha Mangoud	GARBLT
Tatsuo Mukoyama	OCG Bridge Engineer
Tsuyoshi Matsumoto	Chodai Bridge Engineer
Kei Ikegami	JICA Representatice
Dr. Ashraf Elabd	JICA Chief Program Officer
Hana Rady Mohamed	Interpretter

7.2 Result Report (No 1) of Site Survey 1

Date: February 7th 2016, **Time** 14:00, **Place:** GARBLT

Attendances:
From GARBLT: Eng. Hala, Eng. Ali, others
From ACE: Dr. Meguid, Dr. Osman Omar
Polymar: Mr. Salah, Mr. Galal
From JICA: Ikegami, Mukoyama, Matsumoto, Ashraf (Interpreter. Ms. Hana)

Objectives:

- Site Survey Report, Pavement removal, Steel Deck Surface Check, Thickness measurement of Steel Deck Plate, Inspection of inside of the Box Girder.
- Pavement method

Main discussion points and conclusions:

- The JE explained the presentation which summarizes the activities in the last two weeks. Removal of pavements, checking line rusts on the deck plate, measurement of plate thickness, checking fatigue cracks around U-ribs.
- No line rusts were found on the deck plate surface. Almost no possibility of penetrated fatigue cracks of the deck plate.
- After the removal of the pavement of the North lanes, the deck plate thickness was measured along the Bridge from the west end to the bridge center. The thickness of the most corroded point was 11.21mm. But the rusty areas are rather small and the average thickness may be higher than 11.50mm. In 2012 Report, even with the plate thickness of 11.50mm, the stress of the deck plate is below the allowable stress. Then at present, there may be no urgent problems for deck plates.
- U-ribs inside of the box girder were checked. Mainly R8 U-ribs and the places which were checked in 2012 Study. No paint cracks nor fatigue cracks were found.
- GARBLT asked the JE how often U-ribs need to be checked. When U-ribs are checked, UTs or MTs are needed and the cost is not small. The JE requested GARBLT to check U-ribs as often as possible, at least once in 6 months, as there is a maintenance office near the bridge, this may not difficult, at all. Also the JE explained that the eye-inspection is the most important method of inspection. If GARBLT finds some paint cracks or cracks near U-ribs, that is the time when UTs, PTs or MTs are needed. For the eye-inspection, only the man-power is needed.

- As for the pavement method of GARBLT, there are no similar pavements in Japan and the JE cannot comment anything. But based on your experience, the proposed pavement seems to exhibit the good performance. Therefore the JE does not oppose the application of the pavement to the Suez Canal Bridge by GARBLT at its own responsibility.
- JICA requested GARBLT to closely monitor the site works with the JE.

(END)

Attendance list of the meeting with GARBLT & others on Feb. 7th 2016	
Name	**Job title / Organization**
Dr. Eng. Abd El-Maguid	ACE Consulting
Dr. Eng. Omar Osman	Cairo University
Eng. Salah Mostafa	Polymar Co.
Eng. Galal Elmslhy	Polymar Co.
Eng. Ahmed Zayed	GARBLT
Eng. Hala Sayed Helmy	Head of Bridge Sector / GARBLT
Eng. Aly Elsafty Abdallah	GARBLT
Eng. Wafaa Mubarak	GARBLT
Eng. Osama Aly Fahmy	GARBLT
Eng. Essam Taha Mangoud	GARBLT
Tatsuo Mukoyama	JICA Study Team
Tsuyoshi Matsumoto	JICA Study Team
Kei Ikegami	JICA Representatice
Dr. Ashraf Elabd	JICA Chief Program Officer
Hana Rady Mohamed	Interpretter

7.3 Result Report (No 2) of Site Survey 1

Date: February 22nd 2016, **Time** 13:40, **Place:** GARBLT

Attendances:
From GARBLT: Eng. Hala, Eng. Ali, others
From SAMCO: Eng.Ahmed Gad
From ACE: Dr. Meguid
Polymar: Mr. Salah
From JICA: Ikegami, Mukoyama, Ashraf (Interpreter. Ms. Hana)

Objectives:

- Site Survey Report, Pavement removal, Steel Deck Surface Check, Thickness measurement of Steel Deck Plate (East side), Inspection of inside of the Box Girder.
- Pavement work

Main discussion points and conclusions:

- The JE explained the presentation which summarizes the activities in Survey 1. Mainly explained about additional items after Result Report (No1), measurement of plate thickness (East side), Pavement work and the conclusion of Survey 1.The conclusion of Survey 1 is as follows.

  1 We cannot guarantee the success of the application of this pavement that was recommended by GARBLT to the Suez Bridge because of our no experience of this type of pavement. But at the same time based on the experience of same type of pavement to Masara bridge, we do not oppose your application of this pavement to the Suez Bridge at your own responsibility.

  2 Regarding the result of measurement of deck thickness and the result of survey for fatigue cracks, the repair for the Steel deck is not needed.

- Mr. Mukoyama recommended that pull-out test shall be conducted and compare the results with GUSS Asphalt. GARBLT explained that the test might be difficult because equipment is not available.

- Mr. Mukoyama recommended that visual inspection shall be conducted at least once every 6 month after operation of the bridge, especially inside of the box girder for fatigue cracks. GARBLT engineers now have a good experience and they know how to inspect the bridge.

- In case of finding any problems, Ultrasonic Test (UT) and Magnetic Test (MT) shall be implemented as soon as possible.

- GARBLT asked about what they shall do in case they implemented the test and found fatigue cracks.Mr. Matsumoto said that in that case they should stop the traffic on the bridge and consult the fatigue crack specialist as soon as possible. Do not try to repair the cracks by yourself.

(END)

Attendance list of the meeting with GARBLT & others on Feb.22nd 2016	
Name	**Job title / Organization**
Dr. Eng. Abd El-Maguid	ACE Consulting
Eng. Salah Mostafa	Polymar Co.
Eng. Galal Elmslhy	Polymar Co.
Eng. Ahmed Gad	SAMCO
Eng. Hala Sayed Helmy	Head of Bridge Sector / GARBLT
Eng. Aly Elsafty Abdallah	GARBLT
Eng. Wafaa Mubarak	GARBLT
Eng. Osama Aly Fahmy	GARBLT
Eng. Essam Taha Mangoud	GARBLT
Eng. Ahmed Zayed	GARBLT
Tatsuo Mukoyama	JICA Study Team
Kei Ikegami	JICA Representatice
Dr. Ashraf Elabd	JICA Chief Program Officer
Hana Rady Mohamed	Interpretter

7.4 Result Report of Site Survey 2

Date: September 6th 2016, **Time** 11:00, **Place:** GARBLT

Attendances:
From GARBLT: Eng. Osama Fahmy, Eng. Esan Taha, Eng.Desamhy Osman,
Eng. Ahmed Saud
From ACE: Dr. Meguid
From JICA: Ikegami, Ashraf, Mukoyama

Objectives:

- Site Survey Report (South Side), Steel Deck Surface Check, Thickness measurement of Steel Deck Plate, Inspection of inside of the Box Girder.
- Training Seminar

Main discussion points and conclusions:

- The JE explained the presentation which summarizes the activities in Survey 2. The conclusion of Survey 2 is as follows.

  1 Regarding the result of measurement of deck thickness and the result of survey for fatigue cracks, the repair for the Steel deck (South Side) is not needed same as North Side.

- Mr. Mukoyama explained about the maintenance Management Plan as Training Seminar. The contents are as follows.

  1 Pavement

  2 The Repair Plan for the Steel Deck plate

  3 The Reinforcement method of the Steel Deck plate

- GARBLT requested JICA that the following items shall be mentioned in “Chapter 4 Conclusion and recommendation”.

  1 The definite maintenance method shall be mentioned

  2 The reinforcement of Steel Deck plate shall be implemented at the same time as the repair of Steel Deck plate.

(END)

APPENDIX 8 LETTERS

ORIENTAL CONSULTANTS Global Consulting for Sustainable Development

CHODAI CO.,LTD. CONSULTING ENGINEERS & PLANNERS

Follow-up Cooperation Study on the Project for Construction of the Suez Canal Bridge

Date: January 28, 2016

Total: 1page
Your Ref. No. :
Our Ref. No. : OC-GARBLT-001

To: **Authority for Roads, Bridges & Land Transport(GARBLT)**
151 Nasr Road-Nasr City- Cairo-Egypt

Subject: **Advice for the removal method of the rust of Steel Deck plate**

Dear Sir,

We would like to send a letter of our opinion, as follows.

As we explained at the meeting, at GARBLT Qantara office(23rd,January), after the removal of the pavement, it is recommended to blast the steel deck surface to the degree of 3% remaining rust. The degree of 3% remaining rust is shown in the attached sheet.

Your acceptance and signature to this letter would be highly appreciated.

Sincerely yours,
JICA Study Team

Eng/ Ahmed Zayed

Received by :
Mrs. Hala Helmy
Head of Sector for Bridges
of GARBLT

Sent by :
Tatsuo MUKOYAMA
Leader of Study Team
JV of Oriental Consultants Global Co., Ltd.
& Chodai Co., Ltd.

c.c.:
- JICA Egypt Office

Attachment:
- Table for the removal of rust

表 6.7　さびの発生程度標準図および写真例

さびの発生程度	ASTM D610[13]（標準図）	鋼床版のさびの発生状況（現場写真例）	備　考
1 %	 1 %	 1 %程度	● 点さびが少し存在している。
3 %	 3 %	 3 %程度	● 点さびが広範囲にわたって存在している。
10%	 10%	 10%程度	● 部分的に点さび等が集中して発生している。
33%	 33%	 33%程度	● 全面にわたって著しいさびが発生している。
50%	 50%	 50%程度	● 全面にわたって著しいさびが発生している。

〔注〕 1）鋼床版のさびの発生状況には種々の形態があるので，上記の写真にとらわれることなく観察する必要がある。
2）上記写真は，製作後約 2 年間工場のストックヤードに放置されたものを撮影した。

Date: January 28, 2016

Total: 1page
Your Ref. No. :
Our Ref. No. : OC-GARBLT-002

To: **Authority for Roads, Bridges & Land Transport(GARBLT)**
151 Nasr Road-Nasr City- Cairo-Egypt

Subject: **Thickness Measurement**

Dear Sir,

We would like to send a letter of our opinion, as follows. As for the longitudinal measurement positions along the bridge, proposed by ACE consultant, JICA Study Team has no objection. As for the bridge lateral direction, the opinion of the JICA study team is as follows. The line pavement cracks appear as shown in the Photo 1, 2, 3 and 4. Below the pavement cracks, it can be supposed that the rust of the steel plate may progress more easily because the water comes down from the pavement cracks. This may be the reason why the rusts appear on the surface of the steel plate in a manner shown in Photo 10.
From this situation, it would be better to decide the place of thickness measurements across the bridge width after checking the condition of the rust at the position. The places with no rust, the thickness is 12mm. With severe rusts, the thickness may be reduced. Places with more rusts across the bridge width should be checked. The condition of the lateral line across the bridge along which the thickness is measured, should be photographed and recorded. Without the data of the rust along the lateral line, 6 positions are proposed by ACE Consultant, but these positions need to be decided at the site.
Your acceptance and signature to this letter would be highly appreciated.

Sincerely yours,
JICA Study Team

Eng/ Ahmed Zayed

Received by :
Mrs. Hala Helmy
Head of Sector for Bridges
of GARBLT

Sent by :
Tatsuo MUKOYAMA
Leader of Study Team
JV of Oriental Consultants Global Co., Ltd.
& Chodai Co., Ltd.

c.c.:
- JICA Egypt Office

Attachment:
- Fig.1-1,1-2 & Photo

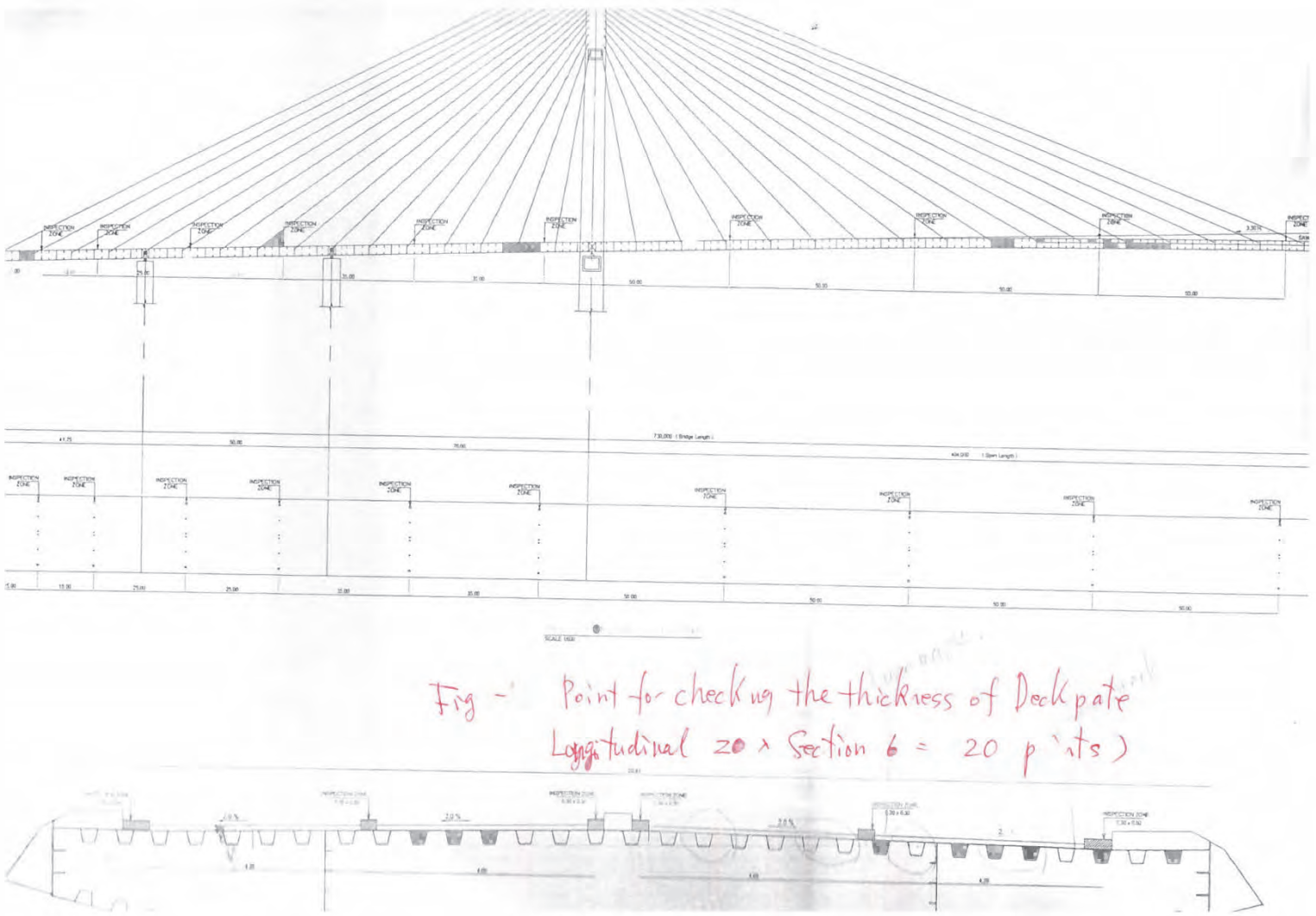


Fig - Point for checking the thickness of Deck plate
Longitudinal 20 x Section 6 = 20 points)

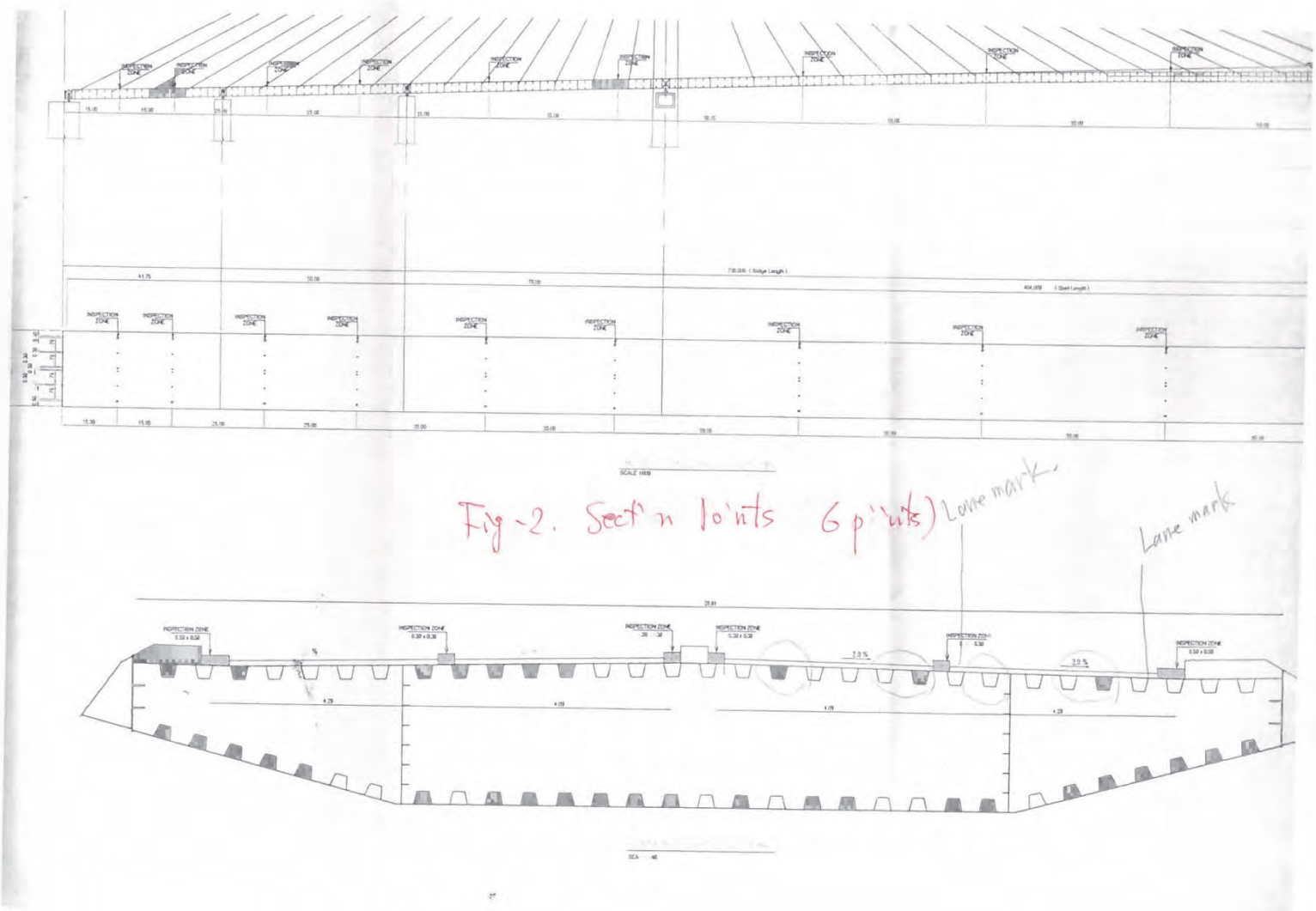


Fig-2. Section Joints 6 points)

Tuesday January 26th, 2016

The Study Team visited the Bridge Site at 10 AM.

1. East side of the bridge and north lanes. Looking towards West on Overtaking Lane. Line repairs of pavements are visible.

2. Driving Lane and 5 lines of pavement repair are visible. These lines correspond to the center of the U-ribs or the center of two adjacent U-ribs. This will be explained in detail, later.

3. In this area, a repair line near the right white line, which is at the center of R4, is visible. But over this line, tires do not run so often and the reason of the crack formation is unclear.

4. On the south lane, the pavement crack over R4 U-rib is not formed.

5. Near the bridge center, a crack line over R4 is not formed.

6. Near the tower, pavement materials were removed and the starving horse is visible. A temporary hand hole is between R4 and R5.

7. The welding line of R4 U-rib below the steel deck, which is 64cm apart from the curb is visible on the left of the brown shoes.

8. Corroded area near the west tower. This may be worst corroded.

9. Corrosion near the west tower and on the North Lane.

10. The corroded areas are on both sides which are below the cracked pavement areas. The center area is healthier.

Date: February 3, 2016

Total: 1page
Your Ref. No. :
Our Ref. No. : OC-GARBLT-003

To: **Authority for Roads, Bridges & Land Transport(GARBLT)**
151 Nasr Road-Nasr City- Cairo-Egypt

Subject: **Opinion about the pavement which GARBLT recommended**

Dear Sir,

We would like to send a letter of our opinions about the pavement which GARBLT recommended as attached.

Your acceptance and signature to this letter would be highly appreciated.

Sincerely yours,
JICA Study Team

Eng/Ahmed Zayed.

Received by :
Mrs. Hala Helmy
Head of Sector for Bridges
of GARBLT

Sent by :
Tatsuo MUKOYAMA
Leader of Study Team
JV of Oriental Consultants Global Co., Ltd.
& Chodai Co., Ltd.

c.c.:
- GARBLT Qantara office
- SAMCO, ACE
- JICA Egypt Office

Attachment:
- Opinion about the pavement which GARBLT recommended

Opinion about the pavement which GARBLT recommended

According to the paper submitted by ACE consultant, Poly Poxy T775 is Tar Epoxy. We did not understand what Poly Poxy T775 is, without this information.

Tar Epoxy is only a painting material which can strongly protect steel materials even on the see water splashing zone. Tar epoxy is employed for the painting of the ship collision buffers of the Seto Ohashi Bridges and it is very effective.

But recently due to its bad effect to the environment, Tar Epoxy will be abolished soon.

We have investigated the application cases in Japan of the Tar Epoxy of 15mm thickness as the lower layer of the pavement. We do not have such a case. We also asked a pavement company, they also do not understand the pavement structure proposed by GARBLT.

From the experience of Japan, it is impossible to advise anything to this pavement. If they test the pull-out test, we can just say that the adhesion test result is good enough or not. We do not know its long time stability, crack resistance, etc.

The 2012 report recommended Guss Asphalt method and we hope GARBLT will apply this pavement.

If they cannot, they may apply SMA method at their own risk. Even in this case, CATICOAT, which is a primer between the water-proof material and the steel deck, and
the SEROSEAL, a water-proof layer, or equivalent of these two, need to be procured from Japan or Germany.

Study Team

Date: February 22, 2016

Total: 1page
Your Ref. No. :
Our Ref. No. : OC-GARBLT-004

To: **Authority for Roads, Bridges & Land Transport(GARBLT)**
151 Nasr Road-Nasr City- Cairo-Egypt

Subject: **Conclusion of Site survey 1 (January & February 2016)**

Dear Sir,

We would like to send a letter of our conclusion of Site survey 1as follows (Please refer attached report)

1 We cannot guarantee the success of the application of this pavement that was recommended by GARBLT to the Suez Bridge because of our no experience of this type of pavement. But at the same time regarding to the experience of same type of pavement to Masara bridge, we do not oppose your application of this pavement to the Suez Bridge at your own responsibility.

2 Regarding to the result of measurement of deck thickness and the result of survey for fatigue cracks, the repair for the Steel deck doesn't need now.

Your acceptance and signature to this letter would be highly appreciated.

Sincerely yours,
JICA Study Team

Received by :

Mrs. Hala Helmy
Head of Sector for Bridges
of GARBLT

Hala

Sent by:

Tatsuo MUKOYAMA
Leader of Study Team
JV of Oriental Consultants Global Co., Ltd.
& Chodai Co., Ltd.

c.c.:
- GARBLT Qantara office
- SAMCO, ACE
- JICA Egypt Office

Attachment:
- Report of site survey 1
- Report of visiting Masara bride

Follow-up Cooperation Study on the Bridge Design(Counterpart Training for the Suez Canal Bridge Project)

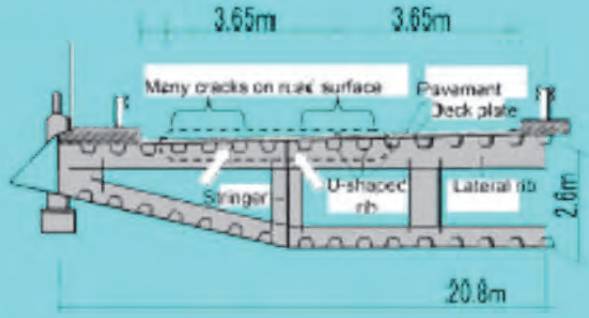
Report of Site Survey 1

February, 2016

Oriental Consultants Global Co., Ltd.
CHODAI Co., Ltd.

Report of Site Survey 1

- The Box Girder consists of 3 cells and the steel deck plate is 12 mm thick, reinforced by U-shaped ribs.



- The top surface of the steel deck plate can be checked visually. Check lines of rust. They can indicate fatigue cracks. If they are found, contact immediately fatigue crack specialists.
- Do not apply heat or welding on the steel bridge deck surface.

Lines of rust were not found. A line of rust can indicate the existence of penetrated fatigue crack initiated from inside of the deck plate. Non-existence of lines of rust does not assure non-existence of fatigue cracks inside. Fatigue cracks around U-shaped rib under deck plate need to be checked.
White areas above are generally healthy. Red areas are rusty to some extent. Both ends of the road surface and the center are often rusty. The average reduction of thickness is not large.

3

Deck plate thickness was measured at site.

Table 1, Measured Plate Thickness (mm)

Distance From Bridge end		North Lane (West Bound, Start to Ingolfig)			
	Point	Corner of Bridge			Bridge Edge
		A	B	C	D
13m	1	11.83	11.70	11.70	11.97
58m	2	11.67	11.97	11.86	11.81
86m	3	11.90	12.01	11.78	12.09
94m	Extra1				11.21
88m	4	12.03	11.91	12.17	12.04
115m	5	11.94	11.97	12.08	12.09
174m	6	11.94	12.09	12.01	11.95
115m	Power				
230m	7	12.10	12.07	11.98	12.01
230m	8	11.88	12.07	11.99	12.01
258m	Extra2	11.87			
340m	9	11.91	12.01	12.15	12.14
350m	10				
346m	Center				

5

Measurement of D6, First & Second Measurement

First measurement 11.97mm

Second measurement 11.66mm

6

Measurement of Extra1, Rustiest spot

Thickness 11.21mm

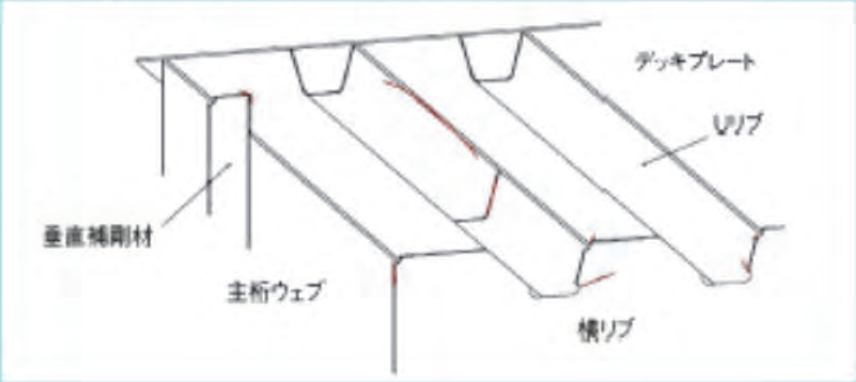
7

When the thickness was measured, two small cuts on the remaining of the lifting piece and the deck plate were found. it was requested to smoothen the cuts at the site, but SAMCO engineer proposed to do so later because a smaller grinder was easy to do so.
This kind of cut should be avoided as far as possible.

8

Inspection under Deck Plate

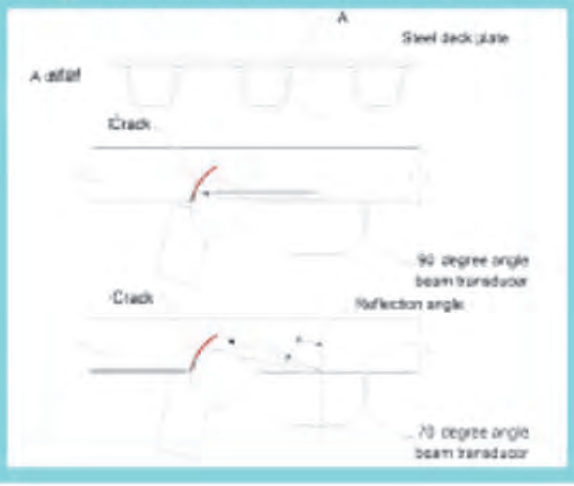
- Visual inspection to detect fatigue cracks around U-shaped rib and longitudinal rib inside steel deck girder.
- Places where fatigue cracks are often found. Check these places. Generally speaking these cracks appear earlier than the deck surface penetrated cracks. Therefore checking back side of deck plate is very important.



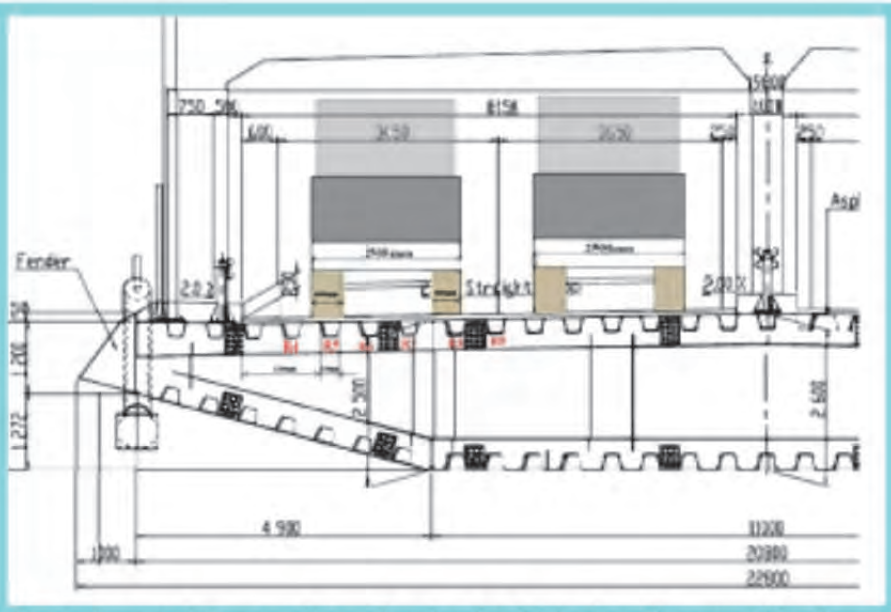
9

Deck Surface Penetrated Cracks, Line of Rust

- The crack initiated from the inside welding bead of U-rib may penetrate the bridge deck. This will result in a line of rust on the deck surface. The Ultrasonic test can detect cracks in the welded joints of the U-shaped rib and the steel deck plate, which cannot be detected by visual inspection.



10



Generally more fatigue cracks are found under driving lane than overtaking lane. Check these places.

11

Some places of R5, R6, R8 U-ribs were investigated in this study, but no cracks were found. But places need to be continuously inspected. If fatigue cracks are found, immediately contact fatigue crack specialists.

L1 Position

L3 Position

L2 Position

C6 Position

12

- In 2012, places shown above were investigated for the plate thicknesses, fatigue cracks, corrosions. The results are listed in the final report, "Follow-up Cooperation Study on the Project for Construction of the Suez Canal Bridge, Final Report, March 2013, JICA". If GARBLT would like to check the condition of the deck plate by themselves, it is recommended to check the same places. For the exact places, please refer to the final report.
- If cracks are found, these cracks were formed after 2012, because in 2012, no cracks were found.

End of Report

13

Report of visiting Masara Bridge

Saturday February 6th, 2016

On 6th February, the Study Team visited the Maasara Bridge in Cairo City, at 11 AM and inspected the pavement and the orthotropic steel deck. The Maasara Bridge was constructed in 1988 when the subway was constructed by French Team. The Maasara Bridge which overpasses the subway was also designed by the French Team. The fabrication was also supervised the French team according to Dr. Meguid of ACE consultant. The pavement of the Maasara Bridge was a different one but it was repaved during January 1st to March 22nd, 1994 by the same specification proposed by the ACE consultant for the SUEZ Bridge. Since 1994, the pavement of the Maasara Bridge has shown the good results. The present condition of the pavement was inspected at the site.

1. The Maasara Bridge over Subway. On the right is the South Lane.

2. The traffic volume is not large but sometimes lager trucks pass.

3. Panels of orthotropic steel deck were fabricated at the shops and transported to the site and assembled. One panel is about 8m long, if lateral rib spacing is 2m, and consists of 6 U-ribs. The U-rib directly above the longitudinal beam is not a U-rib but it consists of two inclined plates.

4. Condition of pavement was quite good and no rust was observed on the deck surface. The yellow color shows the Zinc Chromate. Hexavalent(+6) Chrome is toxic but Trivalent(+3) Chrome is not.

The structure of the orthotropic steel deck panel adopted for the Maasara Bridge resembles the structure of the orthotropic steel deck adopted for the Suez Bridge.

But the longitudinal stiffness of the Maasara Bridge seems to be higher than that of the Suez Bridge, because the space of two U-ribs are supported by two longitudinal beams. (Photo 5) But the space of the longitudinal web of the Suez Bridge is much longer. (Photo 20)

But these two orthotropic steel decks are supported by about 2m interval lateral beams, which are common for both two bridges.

The local area stiffness of the deck plate of these two bridges is similar. But the longitudinal stiffness of two bridges is different. Therefore it is difficult to conclude that this pavement is applicable to the Suez Bridge, as we do not have the experience of the application of this kind of pavement on the long span orthotropic steel deck bridges in Japan.

But at the same time, there is a possibility that the application of this pavement to the Suez Bridge can be successful.

Our conclusion is that we cannot guarantee the success of the application of this pavement to the Suez Bridge but at the same time we do not oppose your application of this pavement to the Suez Bridge at your own responsibility.

Date: September 7, 2016

Total: 1page
Your Ref. No. :
Our Ref. No. : OC-GARBLT-005

To: **Authority for Roads, Bridges & Land Transport(GARBLT)**
151 Nasr Road-Nasr City- Cairo-Egypt

Subject: **Conclusion of Site survey 2 (South Side)**

Dear Sir,

We would like to send a letter of our conclusion of Site survey 2as follows (Please refer attached report)

1 Regarding to the result of measurement of deck thickness and the result of survey for fatigue cracks, the repair for the Steel deck doesn't need now same as North Side.

Your acceptance and signature to this letter would be highly appreciated.

Sincerely yours,
JICA Study Team

Usama Tahny

Received by :

Mrs. Hala Helmy
Head of Sector for Bridges
of GARBLT

Sent by :

Tatsuo MUKOYAMA
Leader of Study Team
JV of Oriental Consultants Global Co., Ltd.
& Chodai Co., Ltd.

c.c.:
- GARBLT Qantara office
- SAMCO, ACE
- JICA Egypt Office

Attachment:
- Report of site survey 2