Appendix8. List of Parties Concerned in the Recipient Country

Appendix 8. List of Parties Concerned in the Recipient Country

(1) GARBLT（General Authority For Roads, Bridges And Land Transport）

Name	Position	1st survey	2nd survey	3rd survey	4th survey
Hon. Eng.Mahmoud Ezz El-Din	Chairman	o	o		
Mr. Ibrahim Ismail Amer	Head sector for Bridge section	o			
Eng. (Ms.) Hala Sayed Helmy	H.G.M. for Bridge Maintenance	o			o
Eng. Sobhe Rabea	H.G.M. for Bridge Maintenance				
Mr. Ali Elsafty Abdalla	G.M. for Bridge Maintenance	o		o	o
Mr.Mohame Farghal	G.M. for Central Lab &Reserch				o
Eng.Khsted Hassana	General Manager of Chairman office		o		
Eng. (Ms.) Wafaa Mobarek	General Manager for Bridge		o	o	o
Mr. Aly Elsafty Abdulla	Sector Engineer, Assistant of Bridge Chairman		o		
Mr.El Morcy Mohamed Elhelw	Head of Central Department for Road Researches	o			
Eng.Abu Bakr Hussein	Central Department for Road Researches	o			
Mr. Tadros Zakhary	Central Lab	o	o		o
Eng. Mohamed Zedan Slama	Project Manager in Road Department				o
Eng. Mostafa Salah Mosteh	Project Manager in Road Department				o
Eng. Samah Hussein	Technical manager of .Asphalt Lab	o	o		
Eng. Rasha Abd Elazz	Civil Engineer in Road Research Departmant	o			
Eng.Mona Khafary	Civil Engineer,Highway and Airport Engineering	o			
Eng.Ola Fawzy	Road Reserch Depertment				o
Mr. Chenigt Mohamed Nagly	Central Lab.Asphalt Lab.	o			
Mr. Baher Mahmoud Mhamed	Engineer of General Central Lab.		o		
Mr. Evelin Nassif Abd.	Quality Manager, Central Lab.		o		
Mr. Hussien Kmal Said Ibrahim	Engineer, Central Road Department		o		
Mr. Sayed Bukheet Ahmed	Engineer, Central Road Department		o		
Mr. Sobhi Rabia Abd El Khalek	Engineer, Road Sector		o		
Eng.Mohamedd Emad Amer	Construction Enginner				o
Eng. Desoky Osman Desoky	Peace Bridge Manager	o	o	o	o

Eng. Ahmed Mohamed Hassan	Bridges Researches Sector	o	o	o	o

(2) Ministry of Transport

Name	Position	1st survey	2nd survey	3rd survey	4th survey
Mr. Mahmoud Allam	Ambassador, Minister Advisor for International Cooperation		o		
Mr. Mohamed Abd El Sabour	General Manager, International Cooperation Unit		o	o	

(3) Ministry of Planning and International Cooperation

Name	Position	1st survey	2nd survey	3rd survey	4th survey
Mr. Nabil Abdel Hamid Hassan	Assistant to the Minister for Asian Affairs		o		
Dr. Nelly Kawal	Officer		o		
Ms. Yasmin Ramadm	Officer		o		

(4) Embassy of Japan

Name	Position	1st survey	2nd survey	3rd survey	y
Kenju Murakami	Economic Counsellor	o	o		
Naruaki Hisada	First Secretary	o	o		
Yasuyuki Matsuda	Second Secretary		o		

(5) JICA Egypt Office

Name	Position	1st survey	2nd survey	3rd survey	4th survey
Nobuhiro Ikuro	Chief Representative		o		
Hideki Matsunaga	Chief Representative			o	
Taro Azuma	Senior Representative	o	o	o	
Shigeru Otake	Senior Representative	o			
Koichi Mizukusa	Representative	o	o	o	o
Ashraf M.El-Abd,Ph.D.	Chief Program Officer	o	o	o	

Appendix9. Minute of Discussion with GARBLT

MINUTES OF DISCUSSIONS
ON THE FOLLOW-UP COOPERATION STUDY
ON
THE PROJECT FOR CONSTRUCTION OF THE SUEZ CANAL BRIDGE
(PAVEMENT FOR STEEL DECK PLATE)

In response to a request from the Government of the Arab Republic of Egypt (hereinafter referred to as "EGYPT"), the Japan International Cooperation Agency (hereinafter referred to as "JICA"), decided to conduct a follow-up Cooperation Study (hereinafter referred to as "the Study"),on the project for construction of the Suez Canal Bridge and the Project for Expansion of the Suez Canal Bridge (hereinafter referred to as "the Original Projects"). From November to December 2011, JICA dispatched the Study Team to Egypt , and through discussions, field surveys and the result of technical examination in Japan, JICA prepared an Interim Report of the Study.

In order to explain and to consult with the officials of concerned authorities in Egypt on contents of the Interim Report, JICA dispatched to Egypt the Study Team for Interim Report explanation (hereinafter referred to as "The Team"), which is headed by Mr. Tomoki Kanenawa, Assistant Director, Grant Aid Project Management Division 1, Financing Facilitation and Procurement Supervision Department, JICA from February 21 to February 29, 2012. The Team continued discussions with the EGYPT side through JICA Egypt Office on some additional issues raised.

In the course of discussions, both sides have confirmed the main items described on the attached sheets. The Team will proceed to further works and prepare the final Report.

Cairo, December 18, 2012

Hideki MATSUNAGA
Chief Representative
Japan International Cooperation Agency Egypt Office

Eng. Ibrahim Ismail Amer
Chairman
General Authority for Roads, Bridges and Land Transport
Arab Republic of Egypt

(Witness)

Ministry of Transport
Arab Republic of Egypt

(Witness)

Samiha Barakat

Ministry of Planning and International Cooperation
Arab Republic of Egypt

ATTACHMENT

I . Result of the Study

The Team explained the Interim Report of the Study as shown in Annex-1 to GARBLT. Summary of the Interim Report is as follows:

(1) Current Situation

- **Pavement**

The cracks occurred constitute 95% of the pavement area. Among of this area, 70% had some cracks with the width of more than 10mm, and most of them are suspected to reach the steel deck plate. The Current situation of pavement is very dangerous to secure safety for passing vehicles and the replacement of the whole pavement is required as soon as possible.

- **Steel Deck Plate**

Corrosions were found on the steel deck plate (which has a thickness of 12 mm). Further thickness reduction due to corrosion of steel deck plate must be prevented in order to secure a soundness of the bridge structure; therefore the removal of the corrosion on steel deck plate is required as soon as possible.

The fatigue cracks were not found in steel deck plate.

(2) Cause of Damage

- **Cracks of Pavement**

At the time of the defects liability inspection in 2003, it was agreed among the parties that the cause of the cracks was passage of heavy over-limited-loaded vehicles, and re-pavement would not be needed if continuous monitoring and proper maintenance would have been carried out. Accordingly. there was no defect liability of the Consultant and the Contractor then in the design and construction on this matter.

Although several repairs have been conducted by GARBLT by adapting the same method of the Contractor (Kajima) since 2003 till now, the hair crack has grown and become major cracks. Given the current situation and the past maintenance record, the Consultant Study states annual repair and pavement replacement once every 10 years are necessary in Egypt.

- **Corrosion of Steel Deck Plate**

It is considered that corrosions of steel deck plate have occurred by rain water penetrated through major pavement cracks and have captured on the surface of the steel deck plate.

(3) Predicted Situation in Future

- **Pavement**

  It is feared that detachment of existing pavement on the steel deck plate would start and expand as a matter of time if replacement of pavement is not implemented immediately, and it would become difficult to secure safety for passing vehicles, and there might be case that the scattered chips of pavement by passing vehicles would fall into the Suez Canal.

- **Steel Deck Plate**

  It is feared that fragmented pavement would cause uneven and excessive stress to steel deck plate and it would induce fatigue cracks in parallel with thickness reduction of steel deck plate due to the corrosion, and reinforcement work for steel deck plate would be required, and finally the bridge would need to be closed from the structural point of view.

(4) Suggestion for repair work

Replacement of the whole pavement and removal of corrosion on steel deck plate are required at present.

(5) Measures until Implementation of repair work

•Pavement

JICA implemented temporary injection work for major cracks in December 2011. GARBLT shall continue to monitor the condition of the pavement and implement temporary injection work for major cracks in order to prevent the detachment of pavement, until implementation of repair work, JICA strongly suggested GARBLT to impose the following traffic restriction on passing vehicles according to the situation of pavement damage.

Situation of Pavement Damage		Traffic Restriction
Level 1	In case of occurrence of new cracks or potholes	Temporary partial traffic restriction for emergency injection work or patch work
Situation of Pavement Damage		Situation of Pavement Damage
Level 2	In case it is difficult to secure safety for passing vehicles in outside lane due to recurrence of potholes or bumps on outside lane in spite of measure of levcl 1	Outside lane closed
Level 3	In case it is difficult to secure safety for passing vehicles in inside lane due to recurrence of potholes or bumps in spite	Inside lane closed

	of measure of level 1	
Level 4	In case it is difficult to secure safety for passing vehicles on whole lane due to recurrence of potholes or bumps in the whole area in spite of measure of level 1	Whole lane closed

•Steel Deck Plate

JICA will install the monitoring device into the pavement in order to monitor the water penetrated inside the pavement and train GARBLT staff on monitoring using it. GARBLT shall continue to monitor the condition of the corrosion on steel deck plate by using the monitoring device and implement the following investigation, in order to prevent the further corrosion on steel deck plate.

Investigation	Method	Effect
Monitoring of water penetration on the steel deck plate	Visual inspection by monitoring hole from the top of the pavement.	To understand the place having a lot of water penetration and prioritize repair of cracks.
Facilitating drainage on the steel deck plate	Installation of drainage pipe inside pavement along the outer shoulder.	To facilitate drainage in the case of remarkable water penetration on the steel deck plate.

(6) Method of repair Based on the results of discussions on several repair method, the Team recommended GARBLT to adopt Guss Asphalt Method as suitable repair option. GARBLT requested JICA for further study of the method of adapting locally available technology and materials (Local SFRC) including method of repair works, bill of quantities, estimated cost based on the local market prices, and the technical specifications for the proposed materials, for the purpose of comparison with Guss Asphalt.

(II) Actions to be taken

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(1) Detailed design

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JICA will implement the detailed design and prepare the tender document for the repair work after the selection of the repair method is completed, and on the basis that GARBLT will implement the repair work..

(2) Implementation of Repair Work

GARBLT will implement the repair work on urgent basis, considering serious situation of pavement condition, risk of traffic accident and looming fear for structural damage.

The repair work would be supervised by GARBLT and /or local consultant hired by GARBLT. To allow for knowledge transfer and to assure the quality of the repair work, GARBLT requested for the consideration of JICA to dispatch member(s) of the JICA Study Team who suggested the repair methods, to be present during the repair work. JICA replied that the dispatch of short-term expert may be considered to advise consultants and contractors hired by GARBLT for the repair works.

(3) Measures until Implementation of Repair Work

GARBLT will monitor the condition of the pavement and corrosion on the steel deck plate, and implement temporary injection work for major cracks appropriately in order to prevent the detachment of pavement until Implementation of Repair Work.

(4) Maintenance of Repair Work

GARBLT will implement the maintenance of pavement appropriately and replace the surface course in a timely manner (expected every ten years) according to JICA's advice in the final report.

(III) Others

(1) Final Report

JICA will finalize the final report on the Study by around January 2013 and hand it to GARBLT through JICA Egypt office.

List of Annex

Annex-1: Executive Summary of Survey and Basic Policy for resolution of the damages.

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Appendix 10.Attached Document to be used for Discussion with GARBLT

February 2012

Follow-up Cooperation Study on the Project for Construction of the Suez Canal Bridge (Pavement on Steel Deck)

Executive Summary of Survey and Basic Policy for resolution of the damages

1. Progress of damage of surface of the Bridge.

The Suez Canal Bridge is the trunk route for land transportation passing over the Suez Canal in the area. As a symbol of the friendship between Japan and Egypt, it was constructed by cooperative works of both countries with Japan's Grant Aid. After it was handed over in September 2001, the bridge was inaugurated in October 2001 as a toll road. In May 2002, the ferry, which had been serviced before opening the bridge, was closed, and Operation of the Bridge was started in earnest. After that, the contractor investigated cracks found on the bridge surface along the westbound lane and partially repaired them. The defect liability period of pavement was extended from one year to two years, and crack repair was carried out as cracks were found. Furthermore, the Authority for Roads, Bridges and Land Transport (hereinafter called GARBLT), the implementation agency in Egypt, started implement of vehicle axle load limitations and other solutions in September 2002. It was expected that those solutions would work effectively to prevent cracks from worsening.

In September 2003, after the inspection for defects liability of pavement had been carried out, the Consultant submitted the analysis report of pavement cracks. The report stated that passage of overloaded vehicles caused cracks and both the implementation of vehicle axle load limitations and further proper maintenance would keep the bridge functional without requiring re-pavement. In addition, repair material was donated as needed by September 2006. And then GARBLT accepted above matter, Defects Liability period ended.

July 2011, it was found that the cracks had developed more comparing to expiration of defects liability, and F/U cooperation study for pavement damage was required from GARBLT. The study had carried out from November to December 2011. As a result of the study, it was determined that about 95 percent of the surface has cracks and the bonding layer was deteriorating. Moreover, a maximum 5 mm loss of thickness of the steel deck plate caused by corrosion was found in the portions of excavation tests, so the urgency of the repair was confirmed.

2. Damage condition

2-1. Pavement cracks

- ✓ Cracks have occurred on more 95 percent of the whole surface area
- ✓ The area with crack widths of 10mm or more is about 70 percent of the whole surface
- ✓ It is expected that cracks with a width of 10mm or more reach into the Binder Layer

Photo-1 Crack Condition

Photo-2 Crack with 10mm width reaches into Binder Layer

2-2. Binding Layer and bonding layer

- ✓ As a result of 6 tensile strength tests, it was found that bonding performance between the steel deck plate and the binder layer is almost lost
  (Averaged tensile strength 0.113 N/mm2 < design tensile strength 1.4N/mm2)
- ✓ On the normal portion without cracks, the bonding layer was sound.

Photo-3 Tensile Strength Test

Photo-4 Failure of Bonding Layer

2-3. Upper side of steel deck plate

- ✓ Corrosion on the steel plate was found at all 5 excavation tests.
- ✓ Maximum thickness loss caused by corrosion is more than 0.5mm; thickness is less than 11.5mm compared with the design thickness of 12mm.

Photo-5 Corrosion roughness on steel deck plate

Photo-6 peeled bonding layer with corrosior

2-4. Fatigue cracks on steel deck plate

- ✓ No fatigue cracks were found in the steel structure elements during the Magnetic Particle Inspection or Ultrasonic Inspection conducted inside of the steel box girders.

3. Damage Cause

3-1. Pavement Cracks

It is supported that; Although after defects liability period GARBLT had continuously carried out repair work to hair cracks, which caused by passage of over-limit-loaded vehicles under uncontrolled axle load limitations at early time after bridge inauguration, crack width and depth had been developed due to insufficient repair measurement by GARBLT, which needed depending on the extension range of the cracks. Moreover, rainwater penetrated into those cracks and the waterproof performance in the bonding layer had been lost. These deteriorations made more cracks develop.

3-2. Corrosion of steel deck plate

Regarding corrosion of steel deck plate, since hair cracks occurred at early

time after bridge inauguration had developed due to the reason mentioned above, rainwater penetrated into the cracks causing the waterproof and bonding performance to be lost, which caused development of more cracks that allowed water penetration to reach to the top of the steel deck plate. Eventfully corrosion occurred on top of the steel deck plate.

4. Regarding responsibility (Construction defect)

4-1. Selection of SMA method for Binder layer

Guss Asphalt method is often applied to binder mixture material among pavement constructions on steel deck plate in Japan, since it is has higher flexibility, water-tightness and bonding performance. On the other hand, SMA (Stone Mastic Asphalt) method has advantages of strength of composite structure containing large amount of coarse aggregate and cellulose fiber as well as of flexibility and bonding performance. In addition to, SMA method allows the use of normal equipments for implementation of constructions. Furthermore, the mixture of SMA had been improved to obtain more resistivity to fluidity at the time of construction. On the view point of considering climatic features in Egypt such as high temperature and little rainfall, procurement of equipment, construction technology and relative construction cost, SMA method was selected for the pavement of the bridge. Consequently, it seems that it was reasonable to select the SMA method at the time of construction.

4-2. Bonding layer

In usual, two layers of Solvent-based Asphalt Rubber are applied as a bonding layer of the SMA. In addition to, three layers was applied to the bonding layer in considering with adjusting to steel deck plate. Total of 0.9 liters per square meter of material was applied in three layers of 0.3 liters per square meter each; two layers of Solvent-based rubber as a waterproof and a Solvent-based Asphalt Rubber layer as finishing. Consequently, it seems that it was reasonable to apply the above bonding layers for the SMA method at the time of construction.

4-3. Pavement cracks

GARBLT had already confirmed, at the time of the defects liability inspection as follow;

The cause of the cracks was passage of heavy over-limit-loaded vehicles at

an earlier time just after the bridge inauguration, not failure of construction by the Contractor. Re-pavement would not need for about a decade if continuous monitoring and proper maintenance would have been carried out after implementation of repair work by the contractor for the initial cracks which occurred just after the bridge inauguration.

4-4. Corrosion of steel deck plate

It is considered that the cause of corrosion was insufficient repair work depending on the extension range of the cracks, which had been caused by over-limit-loaded vehicles just after the bridge inauguration, not failure of construction by Contractor.

5. Predicted Situation in Future

5-1. Pavement cracks

Pot-holes are found at present. Fragments peeled off from the pavement by passing vehicles might possibly scatter and cause serious traffic accidents. And more, if the cracks are not repaired they will allow more penetration of water, which might deteriorate the bonding layer more and cause further development of corrosion on the steel deck plate.

5-2. Corrosion of steel deck plate

There is a possibility of fatigue cracks in the steel deck plate generated by the corrosion on its upper surface.
And since the reduction in the thickness of the steel deck plate must cause greater deformation of the plate itself during live loading, resistance to fatigue will be reduced and further increasing of risk of fatigue cracks in the steel deck plate will be generated. If fatigue cracks in the steel deck plate are generated, further huge cost and effort will be needed for their repair. Therefore, generation of fatigue cracks shall be absolutely avoided.

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6. Measures until Implementation of Repair Work

6-1. Pavement cracks

Temporary injection work for major cracks was implemented in December 2011. Continuous monitoring the condition of the pavement and temporary injection work for major cracks should be implemented in order to prevent the detachment of pavement until implementation of repair work. It is suggested to impose the following traffic restriction on passing vehicles according to the situation of pavement damage.

Situation of Pavement Damage		Traffic Restriction
Level 1	In case of occurrence of new cracks or potholes	Temporary partial traffic restriction for emergency injection work or patch work
Level 2	In case it is difficult to secure a safety for passing vehicles in outside lane due to recurrence of potholes or bumps on outside lane in spite of measures of Level 1	Outside lane closed
	In case it is difficult to secure a safety for passing vehicles on inside lane due to recurrence of potholes or bumps in spite of measure of Level 1	Inside lane closed
Level 3	In case it is difficult to secure a safety for passing vehicles on whole lane due to recurrence of potholes or bumps in the whole area in spite of measure of Level 1	Whole lane closed

6-2. Corrosion of steel deck plate

The monitoring device into the pavement should be installed in order to monitor the water penetrated inside the pavement. Continuous monitoring the condition of the corrosion on steel plate deck by using the monitoring device and the following measures should be implemented in order to prevent the further corrosion on steel plate deck.

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Investigation	Method	Effect
Monitoring of water penetration on steel deck plate	Visual inspection by monitoring hole from the top of pavement	Understanding the place having a lot of penetration. prioritize repair of cracks
Facilitating drainage on upper-side of steel deck plate	install a drainage pipe inside pavement along the the outer shoulder	To facilitate drainage pipe in the case of remarkable penetration on upper-side of steel deck plate

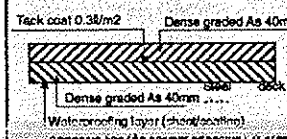
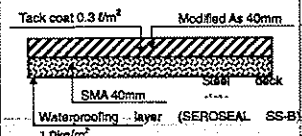
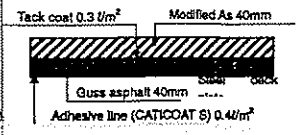
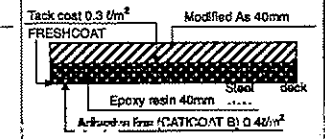
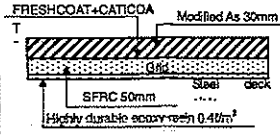
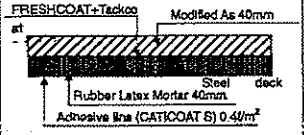
7. Comparison of damage repair methods.

Considering the above, it is necessary to replace and re-construct the surface layer and binder layer (including the bonding layer) on the entire surface of the pavement on the cable-stayed bridge, and remove the corrosion of the steel deck plate completely as soon as possible. A table for comparison of repair methods considered as reasonable at present is shown on the next page.

			Bridge, Haicang Bridge, and Yichang Yangtze River Highway Bridge (China). (normal) - A guideline complies with the Japanese or German specification and the Mediffeddense graded asphalt can be developed by a local construction company.	Europe. Applied are to meny bridges: long-span bridges and Metropolitan highway (Japan); and the 2nd Bosphorus Bridge (Turkey). (good) - A guideline complies with the Japanese or Germen specification and the modifieddense graded asphalt cen be developed by a local construction company.		four years. (normal) - A guideline complies with the Japanese specification and the dense graded asphalt can be developed by a local construction company.	
Cost *1)	Initial Cost	Existing pavement cutting ¥7k/m² x 12,000m² = ¥84 million Sandblasting ¥3k/m² x 12,000m² = ¥36 million Coarse graded As ¥2k/m² x 12,000m² = ¥24 million Adhesive + Waterproofing layer ¥3k/m² x 12,000m² = ¥36 million Dense graded As (tack coat included) ¥2k/m² x 12,000m² = ¥24 million Consultant supervision cost = ¥0 Total = ¥192 million	Existing pavement cutting ¥7k/m² x 12,000m² = ¥84 million Shotblasting ¥5k/m² x 12,000m² = ¥60 million SMA(adhesive CATICOAT + waterproofing layer ¥3k/m² x 12,000m² = ¥36 million Dense graded As (tack coat included) ¥2k/m² x 12,000m² = ¥24 million Consultant supervision cost = ¥60 million Total = ¥264 million	Existing pavement cutting ¥7k/m² x 12,000m² = ¥84 million Shotblasting ¥5k/m² x 12,000m² = ¥60 million GussGuss As (adhesive CATICOAT included) ¥5k/m² x 12,000m² = ¥60 million Cooker (2 sets) + Finisher (2) = ¥250 million Dense graded As (tack coat included) ¥2k/m² x 12,000m² = ¥24 million Consultant supervision cost = ¥60 million Total = ¥538 million	Existing pavement cutting ¥7k/m² x 12,000m² = ¥84 million Shotblasting ¥5k/m² x 12,000m² = ¥60 million Fine graded epoxy resin asphalt ¥4k/m² x 12,000m² = ¥48 million Equipment operation and labor cost ¥1k/m² x 12,000m² = ¥12 million Waterproofing cost ¥2k/m² x 12,000m² = ¥24 million Dense graded As (tack coat included) ¥2k/m² x 12,000m² = ¥24 million Consultant supervision cost = ¥60 million Total = ¥318 million	Existing pavement cutting ¥7k/m² x 12,000m² = ¥84 million Shotblasting ¥5k/m² x 12,000m² = ¥60 million Grid spreading ¥8k/m² x 12,000m² = ¥96 million Highly durable epoxy adhesive ¥7k/m² x 12,000m² = ¥84 million Equipment for concrete pavement ¥4k/m² x 12,000m² = ¥48 million Sheet curing ¥3k/m² x 12,000m² = ¥36 million Dense graded asphalt (CATICOAT included) ¥2k/m² x 12,000m² = ¥24 million Consultant supervision cost = ¥60 million Total = ¥492 million	Existing pavement cutting ¥7k/m² x 12,000m² = ¥84 million Shotblasting ¥5k/m² x 12,000m² = ¥60 million Material + Mixing ¥35k/m² x 12,000m² = ¥420 million Waterproofing (CATICOAT S + FRESHCOAT) ¥3k/m² x 12,000m² = ¥36 million Dense graded asphalt (tack coat included) ¥2k/m² x 12,000m² = ¥24 million Consultant supervision cost = ¥60 million Total = ¥684 million
	Life Cycle Cost (LCC) (for 50 years)	Annual repair and pavement replacement once every 10 years ALL ¥192,000k x 4 times = ¥768 million Repair ¥10,000k x (50-1) times = ¥490 million Total = ¥1,258 million Total cost (Initial cost + LCC 総額) = ¥1,450 million	Repair once every two years and surface course replacement once every 10 years Dense graded As (tack coat included) ¥24,000k x 4 times = ¥96 million Repair ¥10,000k x (50/2-1) times = ¥240 million Total = ¥336 million Total cost (Initial cost + LCC 総額) = ¥600 million	Repair once every four years and surface course replacement once every 10 years Dense graded As (tack coat included) ¥24,000k x 4 times = ¥96 million Repair ¥10,000k x (50/4-1) times = ¥115 million Total = ¥211 million Total cost (Initial cost + LCC 総額) = ¥749 million (¥499 million,if cooker and finisher are rent.)	Repair once every four years and surface course replacement once every 10 years Dense graded As (tack coat included) ¥24,000k x 4 times = ¥96 million Repair ¥10,000k x (50/4-1) times = ¥115 million Total = ¥211 million Total cost (Initial cost + LCC 総額) = ¥523 million	Repair once every four years and surface course replacement once every 10 years Dense graded As (CATICOAT included) ¥24,000k x 4 times = ¥96 million Repair ¥10,000k x (50/4-1) times = ¥115 million Total = ¥211 million Total cost (Initial cost + LCC 総額) = ¥703 million	Repair once every four years and surface course replacement once every 10 years Dense graded As (tack coat included) ¥24,000k x 4 times = ¥96 million Repair ¥10,000k x (50/4-1) times = ¥115 million Total = ¥211 million Total cost (Initial cost + LCC 総額) = ¥895 million
		Initial cost is the lowest compared to other types of pavement, while LCC becomes the highest. (6)	Total cost is the second-lowest compared to other pavements. (21)	Equipment procurement plan must be properly developed. Purchasing needs a great amount of budget unless the equipment would be used frequently. Renting is more cost-effective. (4)	This costs less than SFRC and gussGuss asphalt in which unless the equipment rental is considered. (12)	This costs more than epoxy resin but less than gussGuss asphalt in which unless the equipment rental is considered. (3)	It costs high because of the new technology and no record before. (5)
Review		- Low structural performance is expected due to low flexibility responding to deflection of steel deck plate. (no good) - The ModifiedOrdinary asphalt can be easily made with materials and equipments procurable in the Egypt. (good) - Initial cost is low but total cost including LCC becomes very high. (no good) - Inappropriate to apply the ModifiedOrdinary Asphalt to the pavement of steel deck plate, because its low flexibility may cause damage at the early time and makes it permeable by water so that corrosion acceleration turns into very serious problem. (no good) - Once steel deck plate is damaged and then demands repair, long-term traffic regulation and steel deck plate replacement is unavoidable and costs too much. (no good) No good	- SMA has relatively the low flexibility compared to Gguss asphalt, so that is inappropriate for the pavement of the structure with a large deflection under wheel loading. But, the steel deck plate with 12 mm in plate thickness could use SMA. On November 2011, corrosive damage and plate thickness reduction in steel deck plate has been investigated. As a result, water penetration was found in the pavement. There is no denying that corrosion could grow more. These imply the SMA is inappropriate for use, because corrosive damage may reduce the plate thickness and induce a large deflection of steel deck plate further. (no good) - The SMA can be easily made with normal equipment and materials, but the products - adhesive and waterproofing ilayer ine - need to be procured from Japan or Germany. (good) - Total cost is the second-lowest compared to those of other pavements. (good) No good	- GussGuss asphalt pavement has the features of good flexibility to permit deflection, hard adherence and effective water-tightness. (good) - It can be well developed using special equipment and fluid materials. (good) - The use of cooking carer end paverlinisher costs financially, but if not purchase but rental from Japan or other countries in Europe, it could cost economically. (normal) - The performance and reliability of it have been enough proved from examples in the past. Also the good strength of resisting against plate thickness reduction due to corrosion could be expected because of good adherence, but which is not as much as those of SFRC and RubberGum Latex Mortar. (good) - Rutting problem is less likely to happen because undetected so far in other approach roads. (good) **Good**	- Epoxy Resin pavement has the features of good flexibility to permit deflection, hard adherence and effective water-tightness, but less record requires further quality assurance on the long-term basis. (normal) - Highly-advanced technique is necessary to complete the pavement because the highly durable epoxy resin is employed for the adhesive line. The quality or performance has not been known yet. (no good) - Total cost is the lowest among other pavements but may become higher than that of gussGuss asphalt in which if the equipment rental is considered instead of the purchase. (normal) - Less record of this application in Japan needs the long-term performance assessment. No example abroad by the Japanese guideline is there. (no good) No good	- This represents good performance of decreasing the deflection of steel deck plate and increasing the capacity of strengthening steel deck plate through the composite effect against thickness reduction. (good) - Concrete pavement with the thickness of 50 mm, too much thin, tends to cause shrinkage cracking after completion. (normal) - Total cost is the third lowest, but may be higher than those of epoxy resin as well as gussGuss asphalt in which if the equipment rental is considered instead of the purchase. (normal) - It is very difficult to procure some of the concrete aggregate required for such thin pavement and to perform quality control properly in Egypt. (normal) - Moreover, the durability of steel deck plate could be put at risk again on the long-term basis because the cracking would hamper the function of waterproofing layer. (normal) **Normal**	- This represents good performance of decreasing the deflection of steel deck plate and increasing the capacity of strengthening steel deck plate through the composite effect against thickness reduction. (good) - No result from the long-term performance assessment. (no good) - Materials cost high. (no good) No good

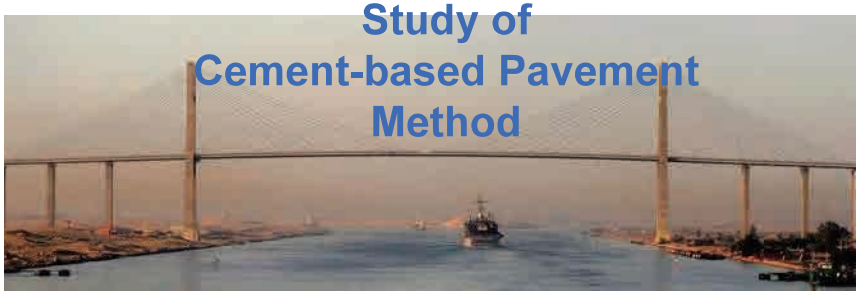
Appendix-77

O Pavement for repair (draft) *NOTE: All pavements are available under the maximum axis weight, 13 ton.*

Type	Steel deck plate pavement				Reinforcement and pavement	
	Ordinary (Dense gGraded) Asphalt	Stone Mastic Asphalt (SMA)	GussGuss Asphalt	Epoxy Resin	Steel Fiber Reinforced Concrete (SFRC)	RubberGum Latex Mortar (RGLM)
Section Structure						
Overview	As the pavement technology especially for steel deck plate is not yet developed in the Egypt, the Ordinarythe Modified asphalt, normally used in concrete deck slab pavement, can be chosen instead. The OrdinaryModified asphalt can be easily made with the equipment which commonly used in other normal asphalt pavement. It lacks water-tightness so to require waterproof layer. Sandblasting is for grinding or abrading the surface of steel deck plate.	SMA wasis developed in Germany for giving a good abrasion resistance to the pavement. In Japan it has been well used as an alternative of gussGuss asphalt, because of its convenience which allows the use of normal equipments and the high water-tightness. SMA includes a large amount of coarse aggregate and cellulose fiber in order to increase the strength of composite structure that leads to the effect of coarse aggregate ligament resisting the internal wearing. Then the high structural durability is obtainable. Shotblasting is used for not only grinding or abrading the surface of steel deck plate but preventing the corrosion occurrence. SMA of steel deck is being developed in Japan for the purpose of improving the flexibility in ways increasing a large amount of asphalt by adding cellulose fiber and grading the size more precisely.	GussGuss asphalt is the first developed in Germany for the pavement of steel deck plate. In Japan sSince 1950s it has been applied in one way of alleviating dead load. In 1970s, in Japan, Honshi has started developing it for the application to the pavement on a long-span bridge. Now many of long-span bridges in Japan are using it. TLA (Trinidad Lake Asphalt, natural asphaltimproved asphalt) is employed under high temperature (220~260°C) to produce Gguss asphalt which is highly fluid. This needs the special equipments, cooking carer and paverfinisher, to carry out appropriate process. No problem has been found over two decades since Honshi-ShikokuRenraku Bridges applied.	Epoxy Resin pavement developed in the U.S has been in recent attempted to the application to steel deck plate in Japan instead of gussGuss asphalt, because of its good flexibility to permit deflection. Fine graded mixture obtained from epoxy resin asphalt is used and does not need uncommon equipment. This pavement is considered as a new technology.	Fatigue crack in recent has been found in over 20-year-old orthotropic steel deck bridge (deck plate thickness = 12 mm) in Japan. The measure that could prevent fatigue cracking and reduce deflection was to develop and apply the SFRC pavement. This is a state-of-the-art technology in suppressing the level of stress concentration in ways providing a strong internal resistance resulted from utilizing the highly durable epoxy resin adhesive between steel deck plate and steel fiber reinforced concrete. This pavement uses common equipment.	Mortar mixed with gum latex consisting of styrene-butadiene spreads over the surface of steel deck plate and hardens to form the pavement, so that would work together with the steel deck plate for enhancing the fatigue durability. This is also one of brand new technologies. This pavement uses common equipment. Test-oriented application is necessary to carry out the long-term performance assessment.
Performance	- Flexibility which permits deflection caused by wheel load is lacking so that may not keep the pavement stuck on steel deck plate. Stripping and damage could take place. (no good) - Highly concerned is low structural performance due to critical defects: pavement cracking, and severe corrosion on the steel deck plate. (no good)	- Good durability is apparent but it is less flexible than Gguss asphalt, so that may weaken the ability of adherence to the surface of steel deck plate. Once the adherence becomes poor, slipping between pavement and steel deck plate would take place to cause cracking in pavement. (no good)	- When traffic volume is expected to increase, the precoated crushed stone pressed into Guss As surfacepavement would contribute to preventing rutting on the surface of road. (good) - Little void inside assures the high water-tightness and demonstrates good waterproofing effect. (good) - Good flexibility can maintain the pavement strongly stuck on the surface of steel deck plate. (good)	- It has a good resistance against rutting. (good) - Little void inside provides the high water-tightness and demonstrates good waterproofing effect. Waterproofing layer is not necessary except where is on the end of pavement. (good) - Good flexibility can maintain the pavement strongly stuck on the surface of steel deck plate. (good) - Epoxy Resin asphalt needs binder componant available only for 3 hours during the period of from production to completion. Once it took over 3 hours, it may not meet quality requirement. (normal)	- This is good for solving fatigue cracking problems and enhancing the composite effect due to combining with steel deck plate. (good) - Concrete pavement may cause easily shrinkage cracking after completion. (normal) - The SFRC pavement with thickness of 50 mm is too much thin so that it is necessary to develop construction plan including epoxy resin adhesive and temperature control. (normal)	- This is good for solving fatigue cracking problems and enhancing the composite effect due to combining with steel deck plate. (good) - The properties demonstrate good performance but it is not obvious to what extent they satisfy fully the structural requirements under the test-oriented application. (normal)
Constructability	- Normal equipment and materials enable the application of the OrdinaryModified asphalt. (good) - Egyptian workers can carry out according to the procedure described in the Egyptian specification. (good) - Resources, such as material and equipment, are procurable in Egypt. (good). - Egyptian engineers can perform quality control. (good) - No record for its application to steel deck plate so far. (no good)	- The SMA can be easily made with normal equipment and materials. (good) - The application has been reviewed for over two decedes by some expressway companies in Tokyo, Osaka, and Nagoya cities in Japan and its specification was then established in 2002. In Nagoya expressway Ssome defects, however, were found in 2007 so that pavement specification has excluded the use of it. Consequently, Gguss asphalt has been considered as a standard pavement on steel deck plate for 15 years. Double-layeredsided SMA was developed and used once in China until damage took place and no longer employed. The SMA is applied to followings: Metropolitan highway (Japan); Suez Canal Bridge (Egypt); Can Tho Bridge (Vietnam); Koror–Babeldaob Bridge (Palau); and Humen Pearl River	- Special equipment is necessary to deal with materials under high temperature. The procedure of construction is rather simple. (good) - Stain on the surface of steel deck plate may bring out blistering problem during pavement. This means Shotblasting should be chosen for grinding or abrading the surface of steel deck plate. (normal) - Most of long-span bridges in Japan have been making use of Gguss asphalt for pavement for 25 years since the Honshi-ShikokuRenraku Bridges applied. GussGuss asphalt has been well known as the Mastic asphalt in some specifications in Europe and the 2nd Bosphorus Bridge is one of bridges as applied. Anticorrosive paint needs zincrich primer and adhesive line requires epoxy resin (eliminator) in	- Normal equipment and materials enable the application of the Epoxy Resin pavement. (good) - Most of orthotropic steel deck bridges in the U.S are employing it and in China recently just started using it. The Kwangyang Bridge in Korea is also one of bridges including it. No defect so far has been found in the U.S but in China did. In Japan, it has been in the test-oriented application to Metropolitan highway for over 1.5 years. (normal) - A guideline complies with the Japanese or U.S specification and the dense graded asphalt can be developed by a local construction company.	- The application needs the use of a concrete pavement finisher and a mixer for agitating steel fibers into mortar. (good) - Concrete pavement with 50 mm in thickness causes hair-like shrinkage cracking. To prevent it, it is important to give close attention to curing and quality control. In Egypt, it would be difficult to apply it because the status of equipment and material procurement, and the level of quality control are not much secure. (normal) - Utilizing the highly durable epoxy resin adhesive needs the advanced technology and is likely to be carried out with many efforts. (normal) - From the past it has been used in Japan's roadways - Yokohama Bay Bridge, National Route No. 50, and Nagoya expressway - for	- Normal equipment and materials enable the application of the GLMRLM pavement. (good) - High durable epoxy resin adhesive is not necessary here, which means it makes it easier to deal with the composite steel deck plate structure for replacement. (good) - Test-oriented application to Yokohama Bay Bridge has been done for two years in the similar way to epoxy resin pavement. The result remains to be seen. (no good) - A guideline complies with the Japanese specification and the dense graded asphalt can be developed by a local construction company.

Appendix-78

Follow-up Cooperation Study on the Project for Construction of the Suez Canal Bridge (Pavement on Steel Deck)



Study of Cement-based Pavement Method

August, 2012

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

Contents

1. Background of the Study

1st Investigation / Dec.2011

It was found that about 95 percent area of the existing pavement had cracks, the bonding layer was deteriorating, and the steel deck plate lost its thickness by corrosion. JICA and GARBLT confirmed that implementation of repair work should be done urgently.

2nd Investigation / Feb.2012

JICA proposed Guss Asphalt Method for repair work based on the result of study.

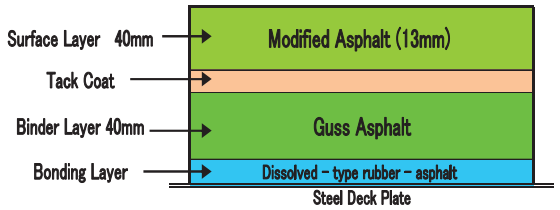
3rd Investigation / May.2012

Although GARBLT appreciated advantage about Guss method, expressed the intention to select cement-based pavement method, expecting that the repair work will be completed by Egyptian contractor with using local material.

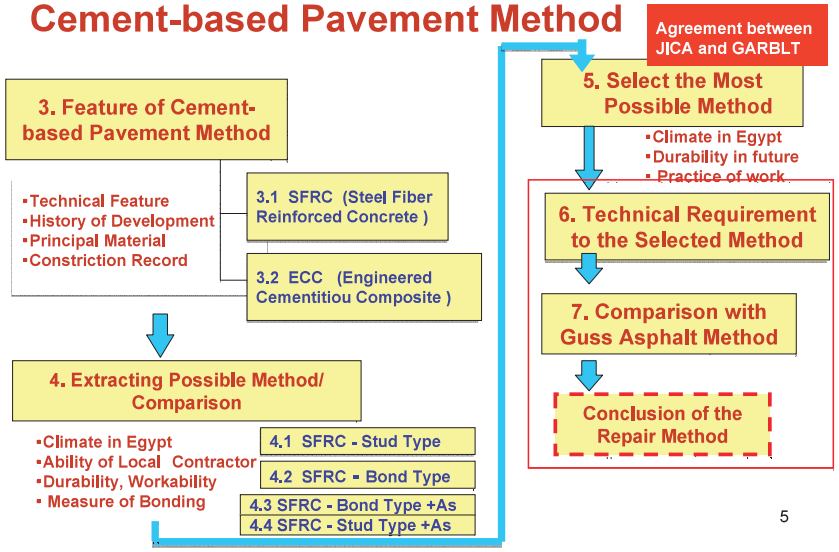
Then, GARBLT requested JICA to study the possibility to conduct th cement-based pavement method under the condition in Egypt.

Guss Asphalt

(Recommended for Repair Method from JICA Study Team in 3rd Investigation May.2012)



2. Flowchart of the Study for Possibility of Cement-based Pavement Method

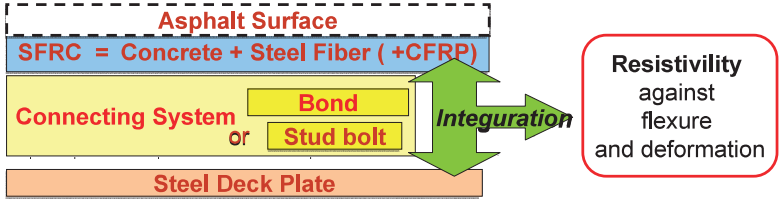


3. Feature of Cement-based Pavement Method

3.1 SFRC (Steel Fiber Reinforced Concrete)

Technical Feature

➢SFRC differs from mere Cement Pavement method.



History of Development of SFRC

➢Developed to improve deteriorated steel deck plate plate in expressway bridges in Japan.

Elements of SFRC

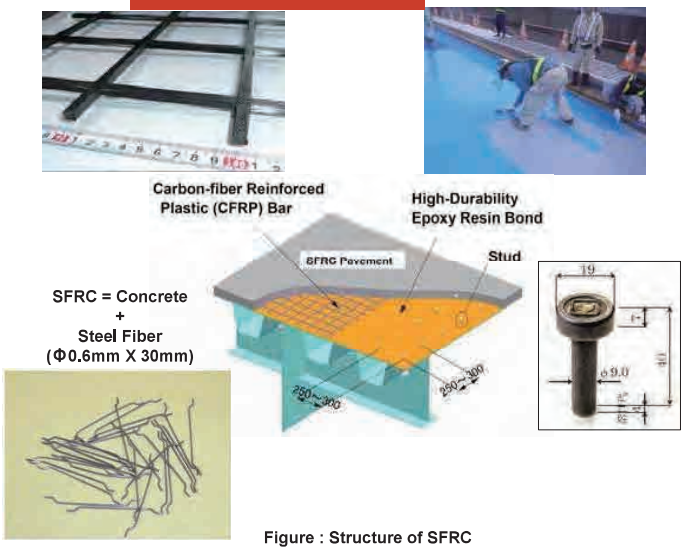
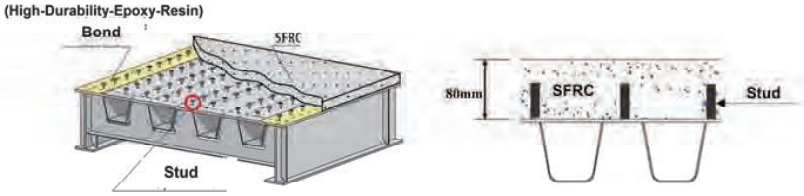


Figure : Structure of SFRC

3.1.1 SFRC with Stud

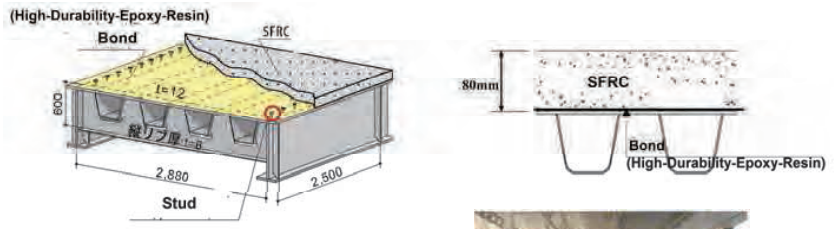
Stud is welded on whole surface of steel deck plate, Bond painted partially (along construction joint, or negative fracture moment portion).



On the case of Nagoya City Expressway in Japan

3.1.2 SFRC with Bond (High-Durability-Epoxy-Resin)

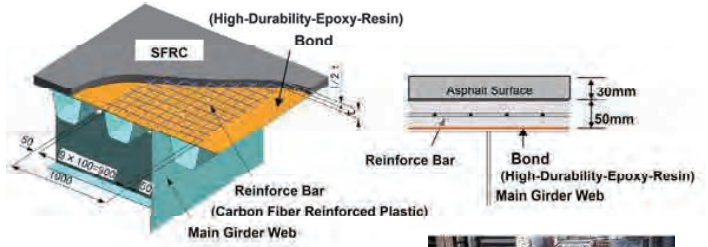
Boning is painted on whole surface of Steel deck plate, Stud installed partially (along edge).



On the case of Yokohama - Bay-Bridge in Japan

3.1.3 SFRC with Bond + Asphalt Surface

Boning is painted on whole surface of Steel deck plate. Reinforced bar (CFRP) is installed on negative fracture portion on the girder. Moreover, Asphalt is surfaced to prevent traffic noise along the route.



(On the case of Tokyo Metropolitan Expressway in Japan

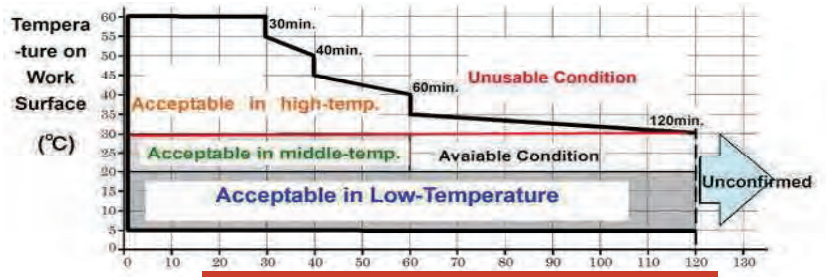
Particularity of High-Durability Epoxy Reign Bonding

- High-durability epoxy resin (HDER) is most superior material possessing adequate strength, durability and workability.
- If substitute material is used, it must have equal quality to HDER.

★ Concrete should be casted before HDER drying.

★ HDER is very sensitive to temperature.

Absolute Requirements on Using HRER



45℃ : 40 min.
35℃ : 60 min.
30 ℃: 120 min.

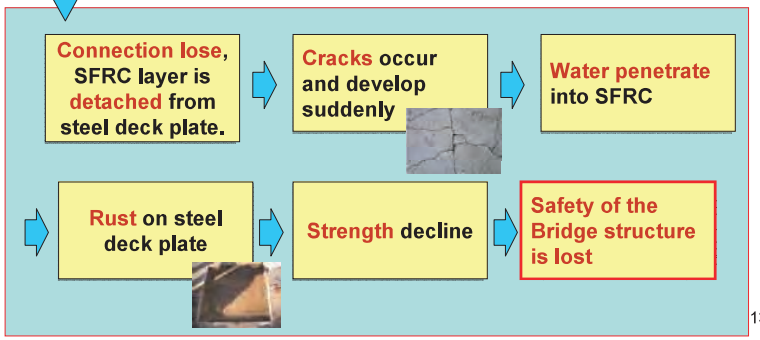
Impossible !

Very Difficult !

If Consecutive Work Failed:

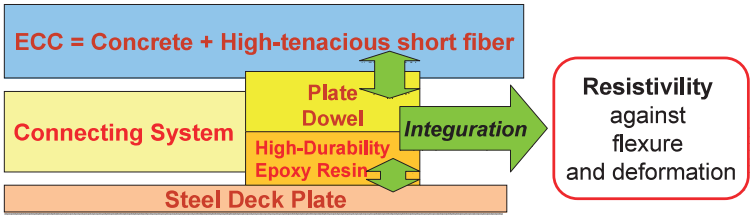
- **Bonding** must possess sufficient performance as; **strength and adequate durability**
- **High temperature** in summer season

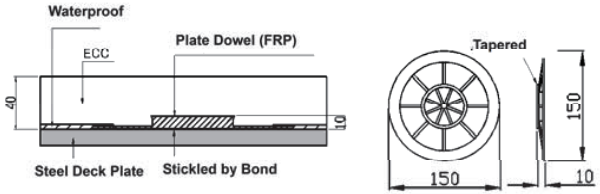
56 degree / Surface of the Bridge
(10AM. 4th June.2012)



3.2 ECC (Engineered Cementitious Composite)

Technical Feature





Construction Record of ECC

Trial-construction of Mihama-Ohashi- Bridge had been executed.

After six months from opening the Bridge ,**damage on the pavement was found,** 2006.

Repair work done, but no drastic improvement.

Overall repair work by **Guss-asphalt** is carried out at July 2012.

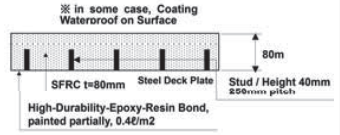
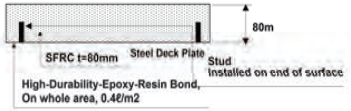
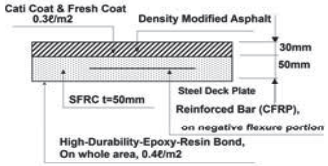
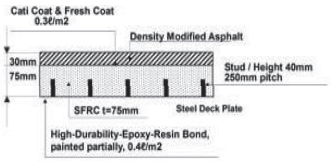
Consequently, **ECC has not reached to practical use.**

4. Extracting Possible Methods/ Comparison

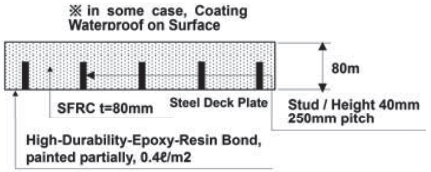
Extractive Conditions

- **Material procurement**, **Capacity of local contractor** and **Climate especially temperatures** ; in Egypt
- **High-durability epoxy resin (HDER)**
  - **Essential material** for SFRC
  - **Not be obtained** in Egypt.
  - **Very sensitive to temperature**
- **Potential of crack** occurring after construction.
- **Public traffic restriction.**
- ECC is excluded because of its fail record.

Extraction

Option-1	Option-2
SFRC- Stud type	SFRC- Bond type
	
Option-3	**Option-4**
SFRC-Bond type + As.Surface	SFRC-Stud type + As.Surface
	

4.1 Option-1: SFRC - Stud bolt type



- **SFRC is 80mm**
- **A vast number stud bolts should be weld on surface.**

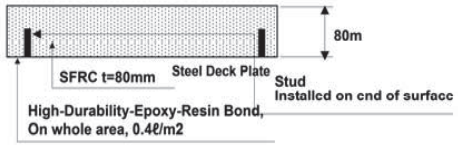
- Limited to doing during winter season.

- High-early-strength concrete is used.
- **Whole closure of public traffic**
  (7 days for concrete strengthening)

- Easy to find crack, after re-opening.
- **3rd low initial cost among options.**

Possible, subject to strict work plan

4.2 Option-2: SFRC - Bond type



- **SFRC is 80mm**
- **High-durability Epoxy Resin is used on whole surface.**

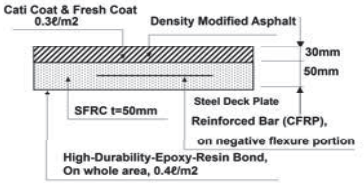
- Limited to doing during winter season.

- High-early-strength concrete is used.
- **Whole closure of public traffic**
  (7 days for concrete strengthening)

- Easy to find crack, after re-opening.
- Lowest initial cost among options.

Very Difficult to Conduct

4.3 Option-3 : SFRC - Bond type + As. Surface



- **SFRC 50mm, As. Surface 30mm**
- **High-durability Epoxy Resin on whole surface.**
- **Shrinkage crack tend to occur due to thin thickness**

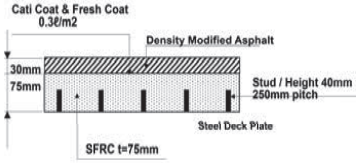
- Limited to doing during winter season.

- High-early-strength concrete is used.
- **Whole closure of public traffic.**
  (7 days for concrete strengthening)

- Difficult to find crack, after re-opening.
- 2nd low initial cost among options.

Very Difficult to Conduct

4.4 Option-4 : SFRC - Stud bolt type + As. Surface



- **SFRC 75mm, As. Surface 30mm**
- **A vast number stud bolts is welded.**
- **Dead load increase, influents durability of bridge structure.**
- **No practical record in Japan.**
  - High-early-strength concrete is used.
  - **Whole closure of public traffic**
    (7 days for concrete strengthening)
  - Difficult to find crack, after re-opening.

Highest initial cost among options.

Very Difficult to Conduct

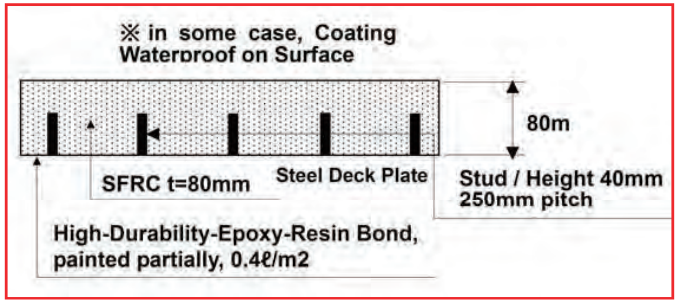
5. Select the Most Possible Method

- **Most important point of selection is workability and durability**
- **Very difficult to practice strictive work plan, on Option 2 &3 (within 120 minuts under 30 degree temp.)**
- **Difficult to detect crack occurring, on Option 3 & 4.**
- **Increase of dead load is unsuitable, on Option 4.**

(In the process of elimination,)

Option 1, SFRC - Stud type is selected as possible method

Stud type (Option-1) is Selected as the Most Possible Method, among Cement-based Pavement Methods



6. Technical Requirement of selected Method

6.1 Preparation by Shot blasting

- Shot-blasting to remove completely rust and existing bonding layer.

  (using special machine)

Standard Figure in ASTM D610	Sample picture
 3 %	

- Removal rang of rust comply with ASTM-D61, less than 3%
- After shot-blasting, primary painting should commenced immediately, to prevent rust on surface of deck plate.

6.2 Quality of Material

6.2.1 Concrete

High-Early-Strength-Concrete

- 29.4 N/mm2 ,
- water-cement ratio is set as less than 50 %, to ensure durability
- Standard mixture condition

Maximum size of coarse aggregate (mm)	15
Cement Type	High-early-strength-cement
Slump after mixing steel fiber (cm)	8 ± 2.5
Water-cement ratio (w/c, %)	Less than 50
Air content (%)	5 ± 1.5
Contamination rate of steel fiber (%)	1.5
Volume of swelling agent (kg/m3)	30

- **High-range Water Reducing Agent , Swelling Agent should be used.**

6.2.2 Steel Fiber

- Both ends should be shaped like hooks in order to improve the adhesion with the concrete.

Properties of the Steel		Steel wire complying with JIS G 3532
Shape		Having hooks at both ends
Dimensions	Diameter	0.6 mm
	Length	30 mm
Tensile strength		600 N/mm2 or more

6.2.3 High-Durability-Epoxy-Resin Bond

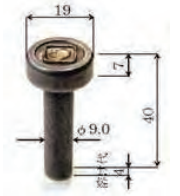
Items	Property
Base compound	Mixing Ratio by weight :5/1 (Base compound/ Hardener)
Hardener	
Specific gravity when cured	1.40 ±0.20
Compressive Strength	50N/mm2 or more
Compressive Elastic Modulus	1000N/mm2 or more
Flexural Strength	35N/mm2 or more
Tensile shear Strength	10N/mm2 or more
Bonding Strength to Concrete	1.6N/mm2 or more
Standard Coating Weight	1.4kg/m2 (manual work)

★**in case of procurement in Egypt, equal performance and strength to be required**

6.2.4 Stud

- Standard space of studs is set 250mm (maximum 300mm, minimum 100mm)
- Standard Criteria

Diameter	9 mm
Diameter of Head	19 mm
Thickness of Head	7 mm
Total Length	40 mm
Welded Thickness	4 mm
Tensile Strength	400～500 N/mm2
Yield Strength	235 N/mm2
Elongation	More than20%



- After welding stud, paint primer around stud to prevent to rust

★**in case of production in Egypt, equal dimension and strength to be required**

6.3 Construction Procedure

①. Removing existing pave.

②.Shot blasting

③. Welding Stud

④. Mixing steel fiber to ready mixed concrete

⑤.Casting concrete

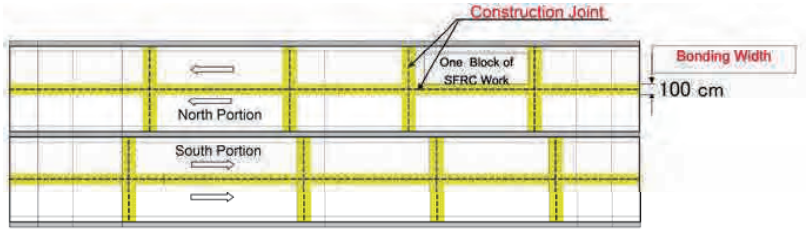
⑥. Compacting by concrete finisher

⑦. Spraying Curing compound

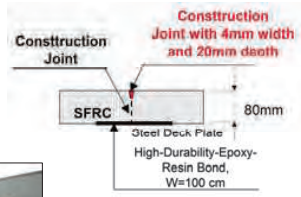
⑧. Covering curing sheet

6.4 Notes on Construction Plan

- Shot-blasting is essential to remove completely existing rust
- Stud should be welded evenly and vertically
- High-Durability-Epoxy-Resin should be painted along construction joint of SFRC.



- Stretchable Joint material is filled along Construction joint of SFRC



- Special concrete finisher should be prepared for adequate compaction to SFRC.

- The repair work under public traffic closure during winter season due to;
  - Avoid vibration by vehicles passing during Concrete strengthening.
- Work including bonding (HDER) within 120minutes under lower than 30 degree temp.

7. Comparison with Guss Asphalt Method

Advantage of SFRC

- Construction Cost :1.59 mil. $ (opt-1), 1.90 mil. $ (opt-4), (Guss: 3.80 mil.$)

Disadvantage of SFRC

- Quality
  - Cracks intend to occur and develop on SFRC.
  - Once, crack developing, water penetration occurs rust on steel deck again.
  - Series Quality Control for High- Early-Strength-Concrete.
  - Risks of remaining rust after sand-blasting, insufficient stud welding and unequal mixing steel fiber.

➢ Constructability

- Constriction Period is about **11 or 19 months.** (Guss : 7 months)
- Concrete shall be casted during winter season. (Dec. to Jan.)
- **Public traffic needs whole closure** due to concrete casting and curing for 7-days. Approximately **one month closure** for each side (south & north) is required. **(Economical and social impacts)**

Guss Asphalt Method is recommended, again

Outline Construction Schedule for SFRC

Months (Case 1) / (Case 2)	1	2	3	4	5	6	7 / 15	8 / 16	9 / 17	10 / 18	11 / 19
Calendar (Case 1) / (Case 2)	8	9	10	11	12	1	2 / 10	3 / 11	4 / 12	5 / 1	6 / 2
Preparation & Procurement											
South Side											
Removal of Pavement											
Blasting and Paint											
Stud Installing											
Bonding - SFRC Layer											
Curing											
Lane Marking											
North Side											

Traffic Closure

Limited in Dec. & Jan.

Traffic Closure

Outline Construction Schedule for Guss Method

Months	1	2	3	4	5	6	7	8	9	10	11
Preparation & Procurement											
South Side											
Removal of Pavement											
Blasting and Paint											
Guss Layer											
Surface Layer											
Lane Marking											
North Side											

Outline Construction Schedule for SFRC

Months	1	2	3	4	5	6	7
Calendar	8	9	10	11	12	1	2
Preparation & Procurement							
South Side							
Removal of Pavement							
Blasting and Paint							
Stud Installing							
Bonding - SFRC Layer							
Curing							
Lane Marking							
North Side							

Traffic Closure

Limited in Dec. & Jan.

Traffic Closure


SHUKRAN
THANK YOU

Appendix 11 Technical Note for Guss Asphalt Method

for Guss

TECHNICAL NOTE
ON THE FOLLOW-UP COOPERATION STUDY
ON THE PROJECT FOR CONSTRUCTION
OF THE SUEZ CANAL BRIDGE (PAVEMENT on STEEL DECK)
IN ARAB REPUBLIC OF EGYPT

In September 2012, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a Study Team on the Follow-up Study on the Project for Construction of the Suez Canal Bridge for pavement on Steel Deck (hereinafter referred to as "the Study") in Arab Republic of Egypt (hereinafter referred to as "Egypt")

The major objectives of the Study are to conduct the detail investigation about the damage on existing pavement of the Bridge and to propose the most suitable repair method based on detail design.

In the course of discussions about repair method between JICA Study Team and GARBLT, both sides confirmed that Guss Asphalt method is adopted for the repair work.

GARBLT confirmed and accepted major undertakings shown below and to conduct repair work in complying with Technical Specification prepared by Study team (see ANNEX-1)

- At tendering of the repair construction, GARBLT should select the well qualified contractors who have adequate ability to conduct the repair work with required construction quality

- On the selection of the awarded contractor, GARBLT should review the capacity of nominated contractors as follow:

  - Construction experience of Guss Asphalt pavement of steel deck plate.
  - Potential capacity to obtaining materials and equipment specified on the Technical Specification.
  - Capacity to conduct the quality test of material used for repair work specified on the Technical Specification.

- In the case that it is found that local contractors have not capacity to conduct the repair work, GARBLT should invite Japanese or international contractor to conduct repair work, or to associate with the Egyptian contractor.

Further, after completion of repair work, GARBLT should continue to review the condition of surface on the bridge. And if necessary to treat the damaged portion on the surface of the bridge, GARBLT should treat it by themselves in the way of adequate treatment measure.

If GARBLT has questions about contents on the Draft Final report, GARBLT is requested to ask to JICA Study Team by letter or e-mail until 20th September 2012.

Cairo, 9th September 2012

Eiji YONEZAWA	Halla Sayed Helmy
Chief Consultant	Head of Bridge Sector
Study Team	For Bridge Maintenance and Construction
Japan International Cooperation Agency	GARBLT

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Pavement Structure of Guss Asphlt Method

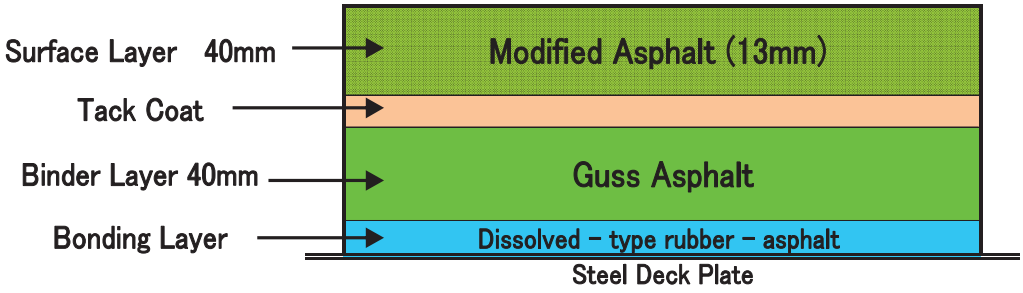


Figure –1 Pavement Structure of Guss Asphalt Method

General View of the Bridge

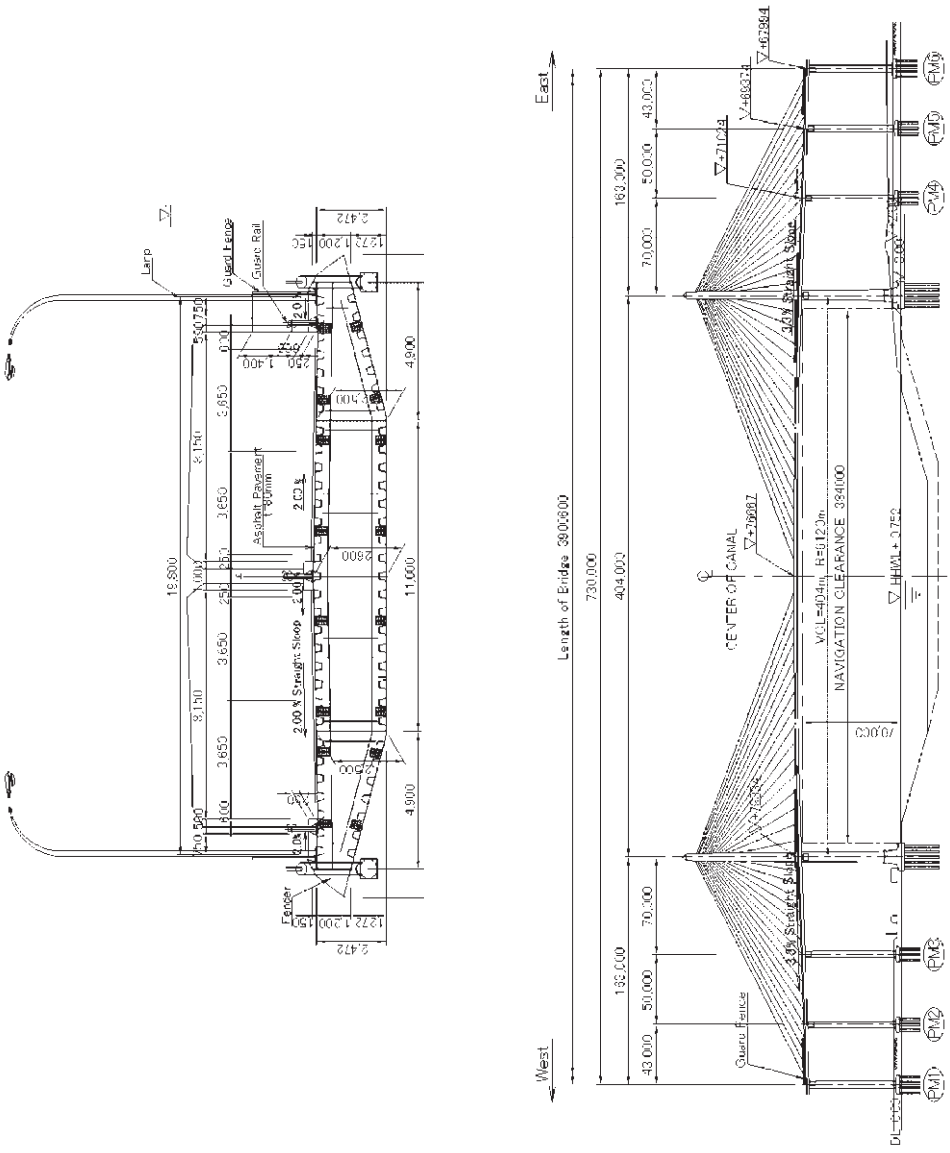


Figure –2 General View of the Bridge

A Removal of Existing Pavement

1 Requirements

(1) The Location to be Removal

- The location of removal of exiting pavement shown as in below figure is whole area on main cable stayed bridge. Existing pavement layers of both Surface course and Binder Course shall be removed.

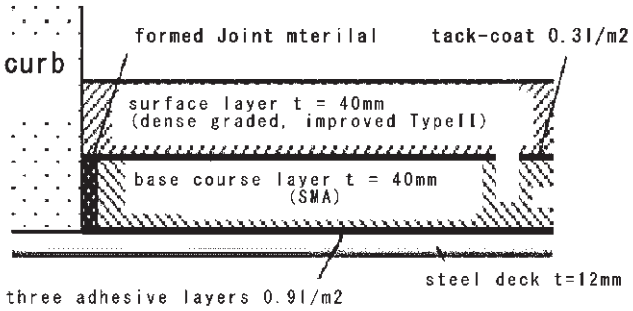


Figure A.1 Existing Pavement Layers

-

(2) Equipment to be used for removal work

- Excavator with bucket capacity 0.45m3 or manual work by labors to break and peel off existing pavement block from the surface of the bridge
- Rock Drill connected to air compressor or manual work by labors as ancillary device to break existing pavement
- 18ton class dump truck for transportation of ruble of pavement block

2. Method of Measurement.

Measurement shall be in square meter of removal of existing pavement concrete completed and accepted in accordance with the Specifications and as directed by the Consultant.

3. Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
001	Removal of Existing Pavement	m2

B Shot-Blasting

1 Requirements

(1) Preparation of steel deck plate

- Preparation of the steel deck for the bonding layer shall be carried out by means of Shot-blasting to remove the existing bonding layer, along with any rust, oil, deteriorated paint, dust, etc. Prior to the Blasting work, the surface of the deck plate shall be made dry. If water or moisture remains on the surface, the wet area shall be dried by using air-blowers or heaters. The Shot-Blasting shall be carried out by projection of steel hemispheres sized from about 1.4 mm to 1.7 mm with a projection density 300kg/m2.
- After the Blasting, the remaining steel hemispheres shall be collected by using Magnets or Dust-collectors.

Shot-blast Projection

Dust-Collector

Photo B.1 Sample Equipment of Shot-blast Projection

(2) Equipment to be used for shot-blasting

- Shot-blast-Projection machines
- Dust Collector for suctioning dust, sediment pilled from surface of steel deck plate
- Track(4ton) with 2.9ton crane lifting product for delivery of Shot-Blasting projection machine and removal of dust

(3) Quality Control

- After shot-blasting work, the surface of steel deck plate shall be well prepared for the

bonding Layer and shall be free from any rust, dust, water, oil, deteriorated paint and any harmful substance. The degree of surface preparation will comply with the criteria of ASTM D610 as follow;

- Residual rate of rust after shot-blasting shall be less than 3 %.
- Checking of the degree of rust removal shall be carried by inspection of five points on 30cm X 30cm area on the place where rust remained, in every 100 m2. The inspection shall be examined by visual on using loupe.
- The degree of rust removal shall be checked in compared with standard figures on ASTM D610.
- If rust has exceeded the 3 %, it will be judged fail and shall be polished again until pass the inspection. Standard figure on ASTM D610 of degree of rust is showed as below.

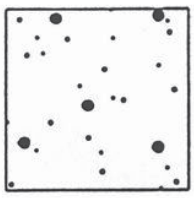
Standard Figure in ASTM D610	Sample picture
 3 %	

Figure B.1 Stanard figure of degre of rust on ASTM D610

2. Method of Measurement

Measurement shall be in square meter of shot-blasted surface completed and accepted in accordance with the Specifications and as directed by the Consultant.

3. Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
002	Shot-Blasting	m2

C Detailed Inspection for Steel Deck Plate

1. Requirement

After Shot-Blasting, in order to examine the soundness of steel deck plate, Magnetic Particle Inspection and Deck Plate Thickness Inspection shall be executed immediately.

(1) Magnetic Particle Inspection

Magnetic particle inspection detects cracks and shows the detailed damage condition, based on information from the visual inspection.

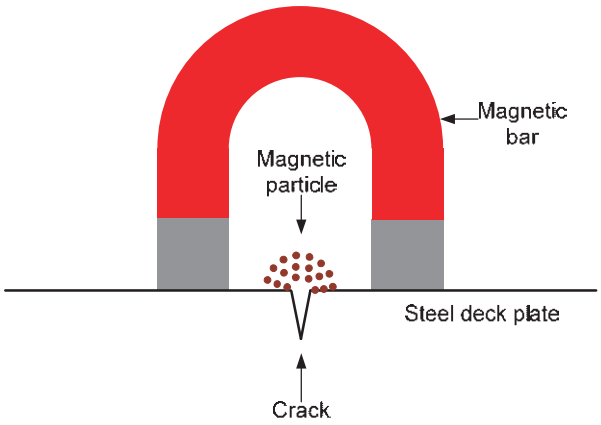


Figure C.1 Magnetic Particle Inspection

The inspection items are as follows:

- Inspection area: South side 9 lines (top of 4 U shaped ribs and 1 web) X 4 m long = 36 m

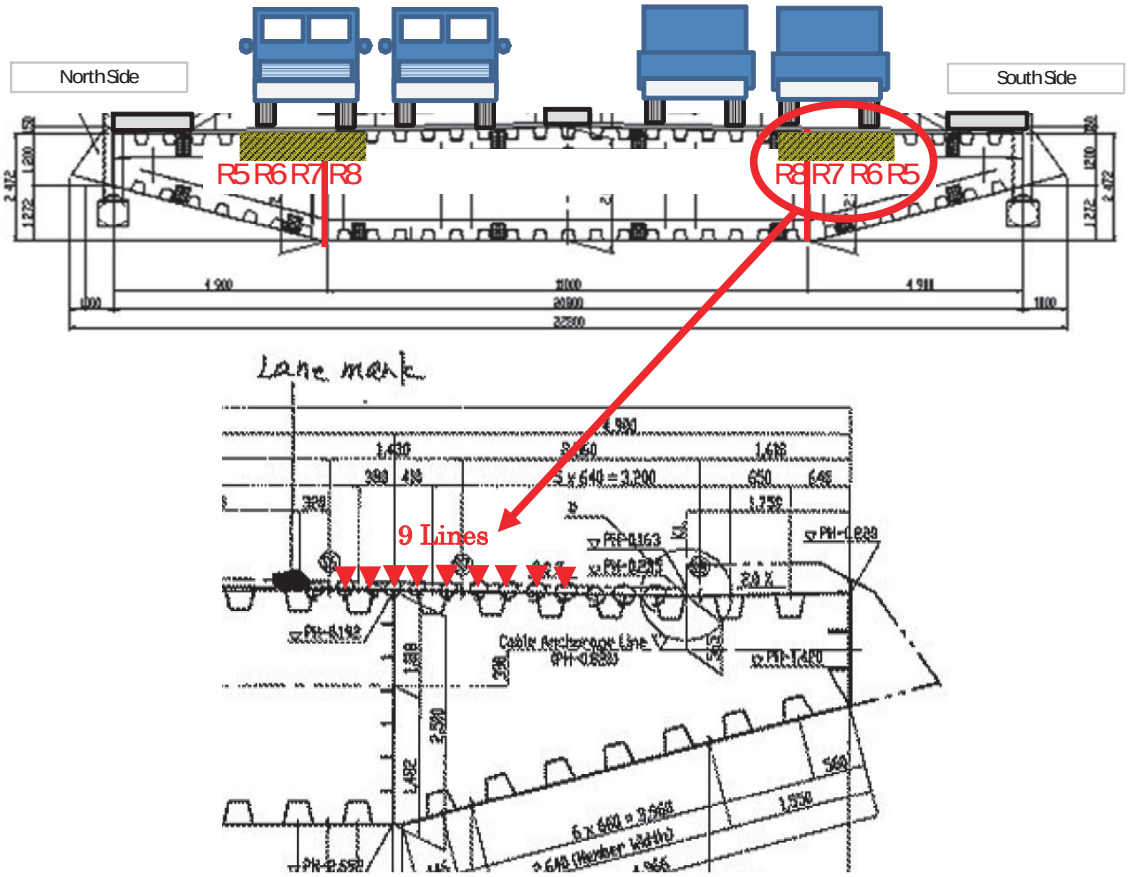


Figure C.2 Location of Magnetic Particle Inspection

- Location of inspection lines shall be determined as the most corroded area by consultant's approval.

- Before magnetic particle inspection, surface of inspection lines on steel deck plate shall be grinded to remove corrosion completely.

- Inspection item: invisible cracks.

- As the corrosion is removed, magnetic particle testing is applied.

- Take pictures of all test steps.

Magnetic particle inspection basically complies with the code specified in the Japan Industry Standard (JIS) and the technician handling it should be eligible for the desirable qualification requested by JIS or the Japan Society for Non-Destructive Inspection. For field application, a self-generating battery and other hand-held devices are used. Plus, an electricity supply cable is added for easy use.

If some fatigue crack will be found, detailed inspection shall be done for other portion. After

identification of cracked area, the repair work of steel deck plate shall be executed by appropriate method which shown in Annex 1.

(2) Deck Plate Thickness Inspection

The plate thickness shall be measured by Ultra Sonic Inspection.

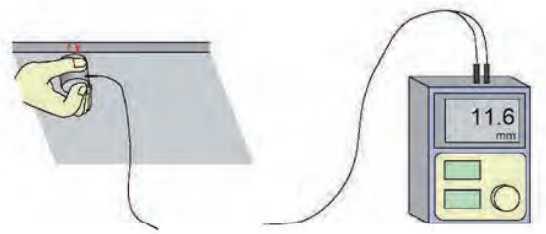


Figure C.3 Plate Thickness Inspection by Ultrasonic Inspection

The inspection items are as follows:

- Inspection area: South side 9 lines (top of 4 U shaped ribs and 1 web) X 4 m long = 36 m.

  (Refer figure C.2)

- Number of inspection point: Every 10 cm pitch along 9 lines of 4 m = 369 points

- Location of inspection lines shall be determined as the most corroded area by consultant's approval.

- Before thickness inspection, surface of inspection lines on steel deck plate shall be grinded to remove corrosion completely.

- Inspection item: plate thickness.

- Inspection method: ultrasonic inspection.

- As the corrosion is removed, ultrasonic inspection is applied.

- The plate thickness is measured and verified by comparing with the original 12 mm.

If measured average thickness in one square meter of steel deck plate will be less than 11.0 mm, detailed inspection shall be done for other portion. After identification of the area where has average thickness less than 11.0 mm, the repair work of steel deck plate shall be executed by appropriate method which shown in Annex 1.

2. Method of Measurement

Measurement shall be in lump sum of the detailed inspection of the steel deck plate completed and accepted in accordance with Specifications and as directed by the Consultant.

3. Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
003	Detailed Inspection for Steel Deck Plate	L.S.

D Epoxy Primer

2. Requirement

Since the surface of the blasted steel deck tends to rust quickly, the subsequent application of the epoxy primer on the surface of steel deck plate shall be commenced immediately.

(1) Material

The Sika-Zinc-Rich 2 or the BASF- MASTERSEAL-1810 shall be used as epoxy primer.

2. Method of Measurement

Measurement shall be in square meter of epoxy primer on the surface of the steel deck plate completed and accepted in accordance with Specifications and as directed by the Consultant.

3. Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
004	Epoxy Primer	m2

E Bonding Layer

1 Requirements

- Coating of bonding layer shall be carried out by manual labor in the way with polite and carefulness.
- Liquid material of bonding layer shall be coated with 0.4 litters per one square meter unit on the surface of the steel deck plate.
- Material of bonding layer, Dissolved – type rubber-asphalt, is applied to primer which shall perform to combine Guss Asphalt binder layer with steel deck plate. Its requirement is shown as below table.

Table E.1 Requirement of Dissolved- Type Rubber Asphalt

Items	Grade	Test method
Drying time in warmed by finger at 23 ºC (min.)	60 or more	JIS K5600-1-1
Nonvolatile Content %	20 or more	JIS K6833
Workability	Not affect to workability	JIS K5600-1-1
Durability	Not abnormal for 5 days	JIS K5600-6-1

2. Method of Measurement.

Measurement shall be in square meter of bonding layer on the surface of the steel deck plate completed and accepted in accordance with the Drawings and Specifications and as directed by the Consultant.

3. Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
005	Bonding layer	m2

F Guss Asphalt Binder Layer

1 Requirements

(1) Material

1) Bitumen

- Guss asphalt mixture to be used for the binder layer is to be made from Petroleum Asphalt mixed with Trinidad Lake Asphalt (T.L.A).
- After mixing the Petroleum Asphalt and T.L.A in a 75:25 weight ratio, the properties of the Guss asphalt mixture shall comply with the quality requirements shown below

Table F.1 Quality Requirements for Guss Ashalt

Property		Grade
Penetration at 25 ºC	1/10mm	15-30
Softening point	ºC	58-68
Ductility at 25 ºC	cm	10 or more
Oven test: Loss-on-Heating	%	0.5 or less
Solubility in Toluene	%	86-91
Flash point, Cleveland Open Cut	ºC	240 or more
Density at 15 ºC	g/cm3	1.07-1.13

- Petroleum Asphalt and T.L.A shall comply with the quality requirements shown below.

Table F.2 Quality Requirements for Petroleum asphalt ant T.L.A

Property		Petroleum Asphalt	T.L.A
Penetration at 25 ºC	1/10mm	20-40	1-4
Softening point	ºC	55.0-65.0	93-98
Ductility at 25 ºC	cm	50 or more	-
Oven test: Loss-on-Heating	%	0.3 or less	-
Solubility in Toluene	%	99 or less	52.5-55.5
Flash point, Cleveland Open Cut	ºC	260 or more	240 or more
Density at 15 ºC	g/cm3	1.0 or more	1.38-1.42

2) Aggregate

- The crushed stone produced from crushed natural rock is used. Quality standard and gradation range standard of aggregate are shown on below tables.

Table F.3 Quality standard for Aggregate

Property		Grade	Test Method
Bulk specific gravity in saturated surfaced-dry g/cm3		2.45 or more	JIS A 1110
Water absorption	%	3.0 or less	JIS A 1110
Abrasion loss	%	30 or less	JIS A 1121
Weight loss	%	12 or less	JIS A 1122
Flat or elongated stone pieces	%	10 or less	-

Table F.4 Grading Standard for Aggregate

Nominal Size	Weight passing Sieves (% by weight)					
Typical Designation	26.5	19	13.2	4.75	2.36	1.18
S-20(No.5) (20-13)	100	85-100	0-15			
S-13(No.6) (13-5)		100	85-100	0-15		
S-5(No.7) (5-2.5)			100	85-100	0-25	0-5

3) Sand

- The sand for the Guss Asphalt mixture shall be natural sand, artificial sand, screenings or mixture of these. Artificial sand and screenings shall be produced from finely crashed stone which comply with table F.5.
- The sand must have proper grading and be clean, hard, and durable without dust, mud, organic material and other harmful substances. The grading range of screenings shall comply with below table.

Table F.5 The Grading Range of Screenings

Nominal Size	Weight of passing Sieves (by weight %)					
Typical Designation	4.75 mm	2.36 mm	600 μm	300 μm	150 μm	75 μm
S-20(No.5) (20-13)	00	85-100	25-55	15-40	7-28	0-20

4) Filler

- The filler shall be made from stone powder made from limestone and other kind of rock, slaked lime, cement, fly ash, recycled dust and others. As a general, stone powder made from crushed limestone shall be used more than 50 % of the total amount of filler. Moisture of stone powder made from crushed limestone is less than 1%, and the grain size of it shall satisfy a range of grain size in the below table.

Table F.6 Grading Standard of Stone Powder from Crushed Limestone for Filler

Sieve size (μm)	Weight passing the sieve (%)
600	100
150	90-100
75	70-100

5) Pre-molded Sealant

- Pre-molded sealant is used for the joint sealant in areas that are in contact with the structure. Pre-molded sealant is a normal temperature bonding joint sealant tape molded from bitumen and rubber, polymer elastomeric material. It is installed used before pavement at the perimeter of a structure where contact with the Binder layer.

(2) Standard Mix Portion of Guss Asphalt Mixture

- The standard mix portion of Guss asphalt mixture for the Binding layer is as shown below.

Table F.7 Standard Mix Portion of Guss Asphalt

Maximum grain size (mm)		13
Weight (% passing the sieve)	19 mm	100
	13.2 mm	95-100
	4.75 mm	65-85
	2.36 mm	45-62
	600 μm	35-50
	300 μm	28-42
	150 μm	25-34
	75 μm	20-27
Asphalt Content %		7-10

(3) Gradation Control

- Aggregate to be used for the mixtures of the guss asphalt binder layers shall be classified by grain sizes. The check and management to the gradation of the aggregates shall be carried out to ensure stability of gradation without debris, mud or deleterious particles.

(4) Design Mix

- The mix design shall be made to satisfy all the requirements in the Specifications

(5) Job-Mix

- In accordance with the design mix portion obtained in the procedure mentioned in above, gradation limits and unit volume of bitumen and other shall be determined, then the job mix shall be carried out for actual production in asphalt plant, and below tests shall be conducted at every time of each design mix.

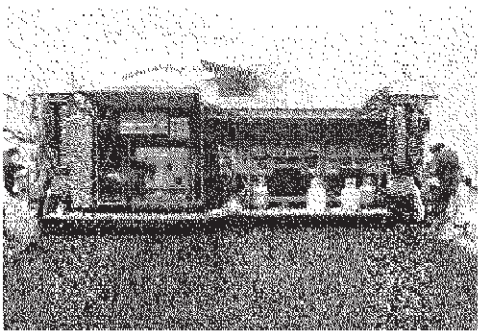
Table F.8 Standard Tests at Job Mixing

Test items		Requirement
Penetration at 40 ºC	1/10mm	20-40
Luel fluidity	second	3-20
Wheel Trucking Test	(Value of dynamic stability)	300 or more
Bending Test for Asphalt Mixture (flexural strain at -10 ºC, 50mm/min)		0.008 or more

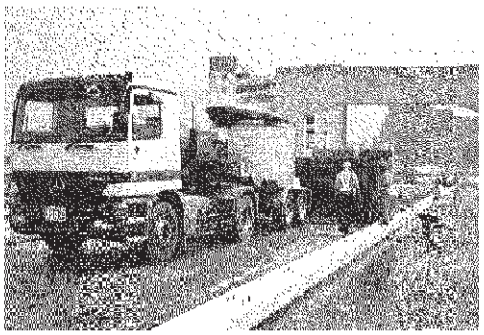
- If necessary, to confirm the final properties of the asphalt concrete mixture. The job mix process shall be executed.

(6) Equipment for Guss Asphalt Binder Layer

- A mobile Special Asphalt Finisher and Cooker used for mixing shall be prepared for construction of Guss Asphalt Binder Layer since the mixture has to be heated to 240 ºC.



Guss Finisher



Guss Mobile Cooker

Photo F.1 Sample of Equipments for Guss Asphalt Pavement

2. Method of Measurement

Measurement shall be in squire meter of Guss Asphalt Binder Layer completed and accepted in accordance with the Specifications and as directed by the Consultant.

3. Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
006	Guss Asphalt Binder Layer	m2

G Tack Coat Layer

1 Requirements

(1) Material

- Either Emulsified Cutback Asphalt or Emulsified Rubberized Asphalt is applied to be used as the bitumen material for tack coat.
- The Emulsified Cutback Asphalt is produced from straight asphalt by adding volatile petroleum solvent in a volume of about 10-40%. It has lower viscosity and high durability.
- The Emulsified Rubberized Asphalt is produced from the Emulsified Asphalt by adding polymer to be improved adhesiveness and durability.
- Standard properties of Emulsified Rubberized Asphalt are shown in below table.

Table G.1 Standard Range of Property of Emulsified Rubberized Asphalt

Property	Grade
Engler degree（25 ºC）	1-10
Residue on sieve （1.18mm, %）	0.3or less
Degree of adhesion	2/3 or more
Electrical charge of particle	positive(+)
Residue; Oven test (%)	50 or more
Penetration at 25 ºC, 1/10mm	60-150
Softening point ºC	42 or more
Toughness(25 ºC) kgf*cm	3.0 or more

Tenacity(25 ºC) kgf*cm	1.5 or more
Strange stability	1 or less

(2) Equipment for spraying of tack coat material

- The machine for spray of material of tack coat shall be used. The pressure of spraying and travel speed of the vehicle will be pre-determined. The ends/corners and next structures will be applied manually. If needed, a cover sheet or similar will be used for protection of curbs or structures from contamination..

Table G.2 Sample of Spraying Equipment of Tack Coat

Name	Capacity	Manufacture
Distributor	10KL	PHOENIX

2 Method of Measurement

Measurement shall be in square meter of tack coat completed and accepted in accordance with the Specifications and as directed by the Consultant.

.

3 Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
007	Tack Coat	m2

H Modified Asphalt (13mm) Surface Layer

1 Requirements

(1) Material

1) Bitumen

- The Bitumen to be used will be straight petroleum asphalt penetration grade 60/70 made

in Egypt

2) Modified Asphalt

- The modified asphalt will be used for asphalt concrete mixture. The modified asphalt will be made from straight asphalt by adding modifying additives. Advanced tests shall be made in a qualified laboratory and dosage of modifying additives will be determined.
- Below table shows the required standard property values for the modified asphalt (Modified Type-III).

Table H.1 Standard Property for Modfied Asphalt (Modified Type-III)

Items	Grade	Test method
Penetration (25ºC,1/10mm)	40 or more	JIS K2207
Softening point (ºC)	70or more	JIS K2207
Ductility (15 ºC, cm)	50 or more	JIS K2207
Flash point (ºC)	260 or more	JIS K2265
Penetration change in Thin Film Oven Test (%)	65 or more	JIS K2207
Weight change in Thin Film Oven Test (%)	0.6 or less	JIS K2207
Toughness(25 ºC) kgf*cm	18 or more	*JEAAS
Tenacity(25 ºC) kgf*cm	-	*JEAAS

*JEAAS: Japan Emulsified Asphalt Association Standard

3) Aggregate

- The crushed stone produced from crushed natural rock is used. Quality standard and gradation range standard of aggregate are shown on below tables.

Table H.2 Quality standard for Aggregate

Property	Grade	Test Method
Bulk specific gravity in saturated surfaced-dry g/cm3	2.45 or more	JIS A 1110
Water absorption %	3.0 or less	JIS A 1110
Abrasion loss %	30 or less	JIS A 1121
Weight loss %	12 or less	JIS A 1122
Flat or elongated stone pieces %	10 or less	-

Table H.3 Grading Standard for Aggregate

Nominal Size / Typical Designation	Weight passing Sieves (% by weight)					
	26.5	19	13.2	4.75	2.36	1.18
S-20(No.5) (20-13)	100	85-100	0-15			
S-13(No.6) (13-5)		100	85-100	0-15		
S-5(No.7) (5-2.5)			100	85-100	0-25	0-5

4) Sand

- The sand for the Guss Asphalt mixture shall be natural sand, artificial sand, screenings or mixture of these. Artificial sand and screenings shall be produced from finely crashed stone which comply with table F.4.
- The sand must have proper grading and be clean, hard, and durable without dust, mud, organic material and other harmful substances. The grading range of screenings shall comply with below table.

Table H.4 The Grading Range of Screenings

Nominal Size / Typical Designation	Weight of passing Sieves (by weight %)					
	4.75 mm	2.36 mm	600 μm	300 μm	150 μm	75 μm
S-20(No.5) (20-13)	00	85-100	25-55	15-40	7-28	0-20

5) Filler

- The filler shall be made from stone powder made from limestone and other kind of rock, slaked lime, cement, fly ash, recycled dust and others. As a general, stone powder made from crushed limestone shall be used more than 50 % of the total amount of filler. Moisture of stone powder made from crushed limestone is less than 1%, and the grain size of it shall satisfy a range of grain size in the below table.

Table H.5 Grading Standard of Stone Powder from Crushed Limestone for Filler

Sieve size (μm)	Weight passing the sieve (%)
600	100
150	90-100
75	70-100

(2) Gradation Control

- Aggregate to be used for the mixtures of the surface layers shall be classified by grain sizes. The check and management to the gradation of the aggregates shall be carried out to ensure stability of gradation without debris, mud or deleterious particles.

(3) Design Mix

- The mix design shall be made to satisfy all the requirements in the Specifications.

(4) Job-Mix

- In accordance with the design mix portion obtained in the procedure mentioned in above, gradation limits and unit volume of bitumen and additive will be determined, then the job mix shall be carried out for actual production in asphalt plant, and tests shown in Table F.8 shall be conducted at every time of each design mix.
- If necessary, to confirm the final properties of the asphalt concrete mixture. The job mix process shall be executed.

(5) Equipment for Modified Asphalt surface Layer

- Asphalt finisher (wide 4.0m class)
- Road roller (Macadam 10-20 ton class)
- Tire roller (8-20 ton class)
- Vibration roller(2.4-2.8 ton class)

Asphalt finisher

Road roller

Tire roller

Vibration roller

Photo H.1 Sample of Equipments for Surface Layer

2 Method of Measurement

Measurement shall be in square meter of tack coat completed and accepted in accordance with the Specifications and as directed by the Consultant.

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3 Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
008	Modified Asphalt (13mm) Surface Layer	m2

I Traffic Line Marking

1 Requirements

- Traffic line shall be marked on the surface of renewed pavement in exactly the same way as to restore previous.
- Three Traffic lines in each directions shall be drawn along center curb, outside curb and mid of carriageway.

2 Method of Measurement

Measurement shall be in linear meter of traffic line painting completed and accepted in accordance with the Specifications and as directed by the Consultant.

3 Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
009	Traffic Line Painting	m

J Pilot Construction of Guss Asphalt

1 Requirements

- Quality and procedures of Guss Asphalt shall be examined by a result of pilot construction work before commencement of construction work of Guss Asphalt pavement of the bridge.
- Pilot construction work shall be executed on the temporally steel deck plate which has at least width of 5 m and length of 10 m on the ground.
- Quality and procedure of Guss Asphalt shall be satisfied the Specifications.
- Result of pilot construction shall be approved by consultant.

2 Method of Measurement

Measurement shall be in lump sum of pilot construction work completed and accepted in accordance with the Specifications and as directed by the Consultant.

3 Payment

The accepted quantities shall be paid at the contract price per unit of measurement for the pay items of the Bill of Quantities listed below.

Pay Item	Description	Unit
010	Pilot Construction of Guss Asphalt	L.S.

Annex 1. Repair Work of Steel Deck Plate

Method of Repair Work

- If fatigue cracks or thickness reduction of the steel deck plate will found by detailed inspection specified in C, appropriate reinforcement work of the steel deck plate shall be executed for damaged area.
- Method of reinforcement work is to apply a reinforcing additional plate as the following figure.

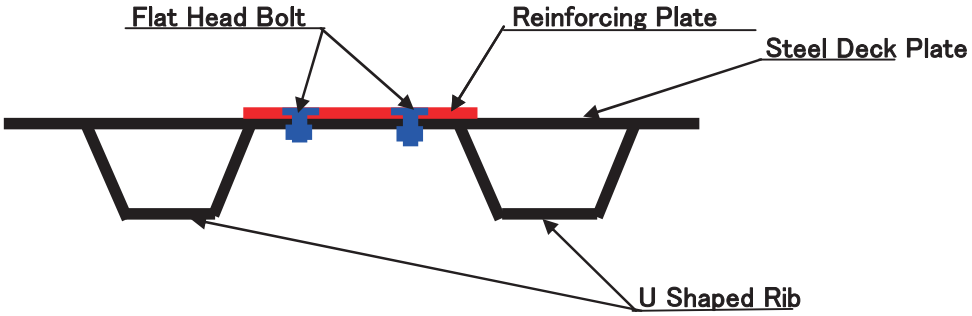

Figure 1 Reinforcing Plate of the Steel Deck Plate

- High tension flat head bolt shall be utilized to secure a flatness of top surface of the reinforcing plate.
- Original steel deck plate and additional reinforcing plate shall be connected by epoxy bonding material.
- Area to be repaired, details of repair method and materials to be used shall be approved by consultant before commencement of repair work of the steel deck plate.

Photo 1 Reinforcing Plate of the Steel Deck Plate

Photo 2 High Tension Flat Head Bolt