STANDARD SPECIFICATIONS FOR BRIDGE REPAIR IN KENYA

Edition 1 | 2024

The Project for Strengthening of Capacity Development on Bridge Management System in the Republic of Kenya

STANDARD SPECIFICATIONS
FOR BRIDGE REPAIR WORKS

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PREFACE

Bridges remain one of the most expensive assets on our roads. During the Bridge Condition Survey done in 2021, it was established that there is a need for critical consideration in the maintenance of these important assets.

The ministry will continue with efforts to streamline operations, asset management practices and implementation strategies improvement to ensure value for money is achieved in infrastructure management cycles.

The Sub-Working Group has proposed that these works are executed by specialised contractors with adequate capacity to carry out the works.

Further, the Sub-Working Group recommends a consistent sustained training plan that will see improvement of bridge asset management practices.

We hope that these specifications will serve the nation well.

Hon. Onesimus Kipchumba Murkomen,
Cabinet Secretary
Ministry of Roads and Transport
P.O. Box 30260 – 00100, NAIROBI.

FOREWORD

These specifications have been developed through support programme from our development partner, Japan International Cooperation Agency (JICA) through the project for strengthening of capacity development on Bridge Management System (BMS) in the republic of Kenya. They have been developed by a Sub-Working Group comprised of experts and practicing Engineers from the road sub-sector and road authorities.

The specifications seek to delineate the scope of works to be undertaken under each work item, define the extents and breakdown the considerations to be made, key elements for consistency, propose a standard order of work in line with best practice and a measurement and payment considerations.

Following detailed stakeholders' inputs and considerations, these specifications shall be anchoring implementation guidance document in Bridge Maintenance schemes and programmes and will help preserve the significant value that the ministry has spent in the development of the critical assets.

These specifications shall be read together with the Standard Specification for Road and Bridge Construction and other attendant standards as indicated.

The Ministry shall be at the forefront in the monitoring of use of these specifications and shall expect compliance by all contract implementation arms of the road sub-sector.

Appropriate review, update and revision provisions have been proposed in the specification to ensure that the specifications take into consideration the changing landscape in materials research, the advancement in technologies and the rapid changes in work methodologies.

The ministry shall support both revisions and updates as time, technology and methods change.

Eng. Joseph M. Mbugua
Principal Secretary
State Department for Roads
Ministry of Roads and Transport
P.O. Box 30260 – 00100, NAIROBI.

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Kenya National Highways Authority (KeNHA)
Kenya Rural Roads Authority (KeRRA)
Kenya Urban Roads Authority (KURA)
Kenya Wildlife Service (KWS)
Kenya Institute of Highways and Building Technology (KIHBT)
National Construction Authority (NCA)
Materials Testing and Research Department (MTRD)
JICA Bridge Management System Project Team

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Yamamoto Hiroyuki	John Agutu	James Nyaga
Victoria Wawira	Wycliffe Magoma	

Eng. J. M. Kung'u
Chief Engineer (Roads),
State Department for Roads
Ministry of Roads and Transport

10100: GENERAL

10101 DEFINITION OF TERMS AND ABBREVIATIONS

TERM	DEFINITION
Abutment	Structural member located at the ends of a bridge connecting the embankment portion of the approach road to the bridge. It supports the load from the superstructure and prevents the lateral pressure from the backfill material.
Ancillary Members	These are structural elements that aid smooth functioning of the bridge, they include the expansion joints, bearings, and approach slab.
Approach Slab	A concrete slab installed behind the abutment to prevent elevation difference from occurring because the fill material behind the abutment settles due to inadequate compaction.
Backwall	The primary component of the abutment acting as a retaining structure at each approach.
Bearing	A device for transmitting forces from the superstructure to the substructure.
Bearing seat	A place where bearings are installed.
Bridge length	The total length of the bridge. That is, the distance between the front of the backwall of the abutments.
Deck	A structural member that directly supports vehicles, pedestrians, etc. passing through a bridge and transmits the load to the main girder.
Drainage facility	Is installed to drain water from the bridge surface. It consists of a drainage basin and a drainage pipe.
Expansion gap	A gap provided to allow for expansion and contraction due to temperature changes. It is provided between a bridge girder and abutment or between girders that are not continuous.
Expansion joint	It is a device installed at the end of a girder or at the gap between girders to ensure smooth expansion and contraction and to allow automobiles and other vehicles to run smoothly on the bridge deck. It is mainly made of steel or rubber.
Foundation	The part of the substructure that is in contact with the ground. Depending on the form, there are different types of foundations such as spread footing, pile foundations, and caisson foundations, etc.
Free board	Height between the bottom edge of the superstructure and the H.W.L.
Girder	The main part of the superstructure that supports all the loads acting on the bridge deck. In general, it is called main girder in the case of girder structure, and main structure in the case of truss or arch structure, etc.

TERM	DEFINITION
Girder length	Length of the main girder.
H.W.L	The planned High-Water Level assumed in the design.
M.H.L	The arithmetic-mean of the high-water heights observed.
Non-structural elements	Elements such as drainage facilities, road restrain systems which perform non-structural functions on a bridge.
Pier	A structural member that transmits the load from the superstructure to the foundation. It divides the bridge into spans.
Road Restrain System	A component designed to prevent vehicles and pedestrians passing over a bridge from falling off the bridge. They include the guardrails, crush barriers etc.
Span length	The distance between two support bearings.
Substructure	Structural members that transfer the load from the superstructure to the ground through the bearings. It is a general term for bridge abutments, piers and foundations.
Superstructure	Part of a bridge that supports the weight of objects passing through the bridge and transmits it to the substructure. It consists of the girder(s), deck, cross beam(s), lateral bracing(s), diaphragm(s) etc.

ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation
ASTM	American Society for Testing and Materials
BS	British Standards
CFP	Carbon Fibre Plate
CFS	Carbon Fibre Sheet
KIHBT	Kenya Institute of Highway and Building Technology
KBS	Kenya Bureau of Standards
NCA	National Construction Authority

10102 GENERAL REQUIREMENTS

General requirements on cross cutting issues for bridge repair, reference shall be made to section 1200 of the current edition of Specification for Roads and Bridge Construction.

10103 HEALTH AND SAFETY

Particular attention shall be paid to the health and safety principles in all works, works environment and workers details in accordance with section 9200 of the current edition of Specification for Roads and Bridge Construction.

10104 TESTS OF MATERIALS

Tests of materials shall be in accordance with section 1700 of the current edition of Specification for Roads and Bridge Construction.

10105 TRAFFIC

Traffic regulation and management shall be in accordance with section 1500 of the current edition of Specification for Roads and Bridge Construction.

10106 SETTING OUT AND TOLERANCE

Setting out and tolerances shall in accordance with section 1800 of the current edition of Specification for Roads and Bridge Construction or as specified by the Engineer.

10107 HOW TO USE THE SPECIFICATIONS

The standards used in this specification comply with relevant Eurocode and ASTM standards where BS standards, equivalent Eurocodes and ASTM standards should be consulted to ensure that specific stipulations for the item under consideration complies with the most current standard requirement applicable at that time.

10108 REQUIRED PERSONNEL

For all works to be executed under this specification, skilled personnel appropriately trained by KIHBT and registered and accredited by NCA should be involved in works execution.

For specialised works that require particular directions from the manufacturer, the Engineer will request the presence of the manufacturer's representative.

10200: CLEANING

10201 SCOPE OF SECTION

This section covers cleaning of all components of a bridge. All cleaning work shall be performed to provide the surface or bridge section with the cleanliness required. The drawings and Engineer's instructions shall specify the sections or locations of cleaning.

10202 GENERAL

Cleaning shall involve removal of all deleterious, foreign and unwanted materials on the structure surface, parts and or sections. Cleaning shall involve the initial works proposed for health and safety preparatory as per clause 10103 of this specification.

The removed materials shall be collected and disposed at an approved waste area in accordance with waste management guidelines. These materials SHALL NOT be disposed into the river or on dry land portions below the bridge.

Regardless of the equipment or method chosen, all bridge components SHALL NOT be damaged in any way by the cleaning operation. Any damage caused by the Contractor's operations shall be promptly repaired at the contractor's expense.

10203 DEFINITION

The definition of parts to be specified shall comply with the bridge parts as indicated in clause 10101 of this specification.

10204 APPLICABLE STANDARDS

The cleaning shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent Eurocode:

BS 8221-1	Cleaning of natural stone, brick, terracotta and concrete
BS 7079	Cleaning of steel surfaces

10205 MATERIALS

Cleaning equipment shall consist of hand tools, high pressure water blaster, water tank, and water pump with associated delivery hardware necessary to properly flush, clean, and remove all foreign, deleterious materials from the bridge structure. Other types of cleaning equipment may also be used subject to the approval of the Engineer.

Clean water is recommended as a cleaning material.

Other equipment such as inspection vehicle, access trucks or movable scaffolding devices may be necessary to access the areas to be cleaned.

10206 ORDER OF WORKS

Set up for works shall comprise of the bridge deck, median, curb and sidewalks, all accumulated dirt and debris and dispose of it prior to washing. Removal of accumulated material shall be performed using hand brooms, hand shovels, scrapers, vacuum cleaners or other methods acceptable to the Engineer, moving the debris toward the ends of the bridge, to keep it from entering the river.

Cleaning can involve the use of water to wash the bridge components with appropriate water pressure machines and brooms. Starting with the top most components going downwards or as instructed by the Engineer. When washing the deck, the drains on the bridge deck shall be blocked so that the water that has blasted the dirt and debris can be directed off the ends of the bridge, into the roadside vegetation. That way, the water used to wash the bridge is filtered by the earth.

When washing overpass structures, care shall be taken to ensure that dirt or debris is not deposited on vehicles or pedestrians passing below.

10207 MEASUREMENT AND PAYMENT

Item: Cleaning

Unit: m^2

This work shall be measured for payment by the actual area in square meters as sum of all areas of components cleaned as specified in this specification.

This work will be paid based on a unit price per square meter for "Cleaning", complete in place, which shall include all materials, containers, equipment, tools, labour, services of the technical service advisor, and work incidental for the cleaning of the structure. There will be no direct payment for the cost of storage or hauling and other materials to and from the bridge(s), or for the containment, collection, and storage of hazardous or contaminated materials within the work areas. The cost thereof shall be deemed included in the price per square meter.

10300: TOUCH-UP PAINTING

10301 SCOPE OF SECTION

Work under this item shall consist of field touch-up painting on steel at localized areas. This section covers preparation of all the steel surfaces, containment and collection and storage of paint debris. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

10302 GENERAL

Touch-up painting is done to prevent corrosion. This work only covers painting to small areas where hand and power tool preparation is the only feasible method. Large areas, where sand blast cleaning can be justified, should be painted in accordance with section 12200 of this specification.

10303 DEFINITIONS

Touch up refers to the improvement of the appearance of a surface by applying paint to small areas that are damaged.

Anti-corrosion paint refers to a special paint used to stop rust from taking place.

Thinner refers to a solvent used to make paint less viscous.

Aluminium paint refers to a paint that is solvent-based and filled with aluminium flake.

10304 APPLICABLE STANDARDS

The anti-corrosion paint used for touch-up coating shall be in accordance with the provisions of the relevant clauses of the following ASTM Specification or equivalent British Standard or Eurocode:

ASTM D7234, BS EN ISO 4624:2016	Adhesive test
ASTM C190, BS 3900	Elongation
ASTM D6943, BS 3900	Saltwater test

The material shall be approved by the Engineer through certificate of compliance by the contractor or through test results from the stockpile.

The aluminium paint shall be in accordance with the provisions of the relevant clauses of the following ASTM Specification or equivalent British Standard or Eurocode:

ASTM-D1730, BS 3900-F20: 2004	Standard Practices for Preparation of Aluminium and Aluminium-Alloy Surfaces for Painting

10305 MATERIALS

1. Aluminium Paint (locally available)
2. Thinner
3. Anti-corrosion Paint

The contractor shall comply with the provisions of Clause 1722 of the Standard Specification for Road and Bridge Construction on Paints for Structures.

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

10306 ORDER OF WORKS

1. Preparation of the Steel Surface

Depending on the severity of corrosion on the members, the old coating film rust shall be removed with a disc grinder, scraper or wire brush, partially revealing the steel surface. Sharp ridges and deep narrow grooves or pits shall be removed from the steel surface using power grinder. However, where depth of roughness is less than 0.5 mm adequate and durable paint system can be achieved without multiple coats of surface levelling paint. Each coat shall not be more than the maximum film thickness recommended by the manufacturer.

2. Time for Touch-up Painting.

The paint shall be applied immediately after surface preparation or within 4 hours after surface preparation for painting operations.

3. Painting operations.

a. Preparation for painting operations

i The surface to be coated shall be thoroughly cleaned free of dust, sand, oil, grease and other harmful substances. If sea salt particles are thought to be adhering to the surface to be coated, the surface shall be thoroughly rinsed before painting.

ii Areas where painting is not to be carried out shall be masked to prevent paint from adhering to them.

iii The paint to be used shall be adjusted to the appropriate viscosity according to the painting method, the amount of paint applied and the temperature at the time of painting. In this case, if a diluent (thinner) is unavoidably used, the amount of the diluent shall be kept to a minimum, weighed accurately and added, and the diluent shall be from the same manufacturer as the paint. However, diluents shall not be used for solvent-free paints.

b. Paint application

i On-site painting shall be based on brush application and airless spray application.

ii When multi-component paint mixtures are used, paint that has exceeded its pot life shall not be used. Wet paint shall be used as appropriate during painting.

iii Wet film gauges shall be used to control film thickness as necessary during the coating process. The correlation between wet film thickness and dry film thickness for each paint to be used should be obtained from the paint manufacturer in advance.

4. Conditions prohibiting painting work

Coating SHALL NOT be carried out in the following conditions:

a. Where temperature and humidity are not in accordance with the coating standards.

b. In the case of outdoor painting; when it rains, or strong winds occur or are likely to occur.

c. When the painted surface is wet due to condensation, etc. and is expected to remain so.

d. When the surface temperature of the painted surface is below the temperature specified in proper criterion or above 50°C.

e. When foreign matter and deleterious materials is expected to adhere to the surface during drying (curing) of the coating film.

f. When the surface preparation is not carried out as specified.

g. When the specified intervals between coats have not been taken.

h. When mud, oil, grease, dust, etc. adhere to the painted surface.

i. If the paint used has exceeded the specified usable time.

j. If the paint is not sufficiently mixed, agitated or diluted.

k. In other cases where the Engineer considers it inappropriate.

5. Coating intervals

The interval between coats shall be within the limits specified for each coating system. In this case, the coating shall be applied after the lower coating has sufficiently dried (hardened) and the coating has hardened.

6. Inspection

The painted surface shall be inspected after painting is completed and if there are any coating defects, the surface shall be repainted as soon as possible in accordance with the Engineer's instructions.

7. Work control

The work management personnel shall ensure the following:

a. Paint to be used shall be within the date of manufacture and expiry date (generally within 1 year of manufacture).

b. After the paint cans have been opened, the condition of the paint shall be checked, including the state of the coating skin, colour separation, solidification (gel), separation and colouring.

c. For multi-component paint mixtures, the mixing ratio and whether the paint is used within the usable time after mixing.

d. Dilution of paints by diluent (thinner), the proportion and viscosity of the paint to be applied.

8. Storage of paint

Paint and diluents shall be handled with care and the quantity and method of storage shall be in accordance with the relevant standards and manufacturer's instructions.

9. Environmental conditions for work.

a. Weather conditions such as temperature, humidity, wind speed, wind direction, condensation, etc, shall be in accordance with the manufacturer's specifications and/or Engineer's instructions.

b. Workability: Scaffolding, installation method of materials, etc.

10. Conditions of the surface to be coated.

a. Before touch-up and before the first layer of primer coating, the surface shall be free from moisture, oil, grease, dust, rust, slag, abrasive, etc. as specified in the preparation.

b. For the second and subsequent layers of coating, it shall be ensured that the underlying coating is suitable for the layers to be painted over. In addition, there shall be no adhesion of moisture, oil, grease, dust, rust, slag abrasive, etc. and no defects in the coating film.

10307 MEASUREMENT AND PAYMENT

Item: Touch up painting

Unit: m^2

This work shall be measured for payment by the actual area in square meters of steel surfaces cleaned, painted and accepted.

This work will be paid based on a unit price per square meter for "Touch-up Painting", complete in place, which shall include all materials, equipment, tools, labour, services of the technical service advisor, and work incidental for the touch up painting of the structure. There shall be no direct payment for the cost of storage or hauling of the paint and other materials to and from the bridge or bridges to be painted, or for the containment, collection, and storage of hazardous or contaminated materials within the work areas. The cost thereof shall be deemed included in the price per square meter.

10400: EPOXY COATING

10401 SCOPE OF SECTION

This section covers preparation of concrete surface (cleaning of cracks), application of epoxy sealant, curing and monitoring of crack width. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

10402 GENERAL

Epoxy coating on the crack shall be performed considering the size of cracks, variations in crack width, and other conditions. This method shall be generally applied for cracks with less than 0.3 mm width. It shall be applied to concrete structures to repair, horizontal, vertical or overhead cracks (ceiling cracks). The repair shall be undertaken as instructed by the Engineer.

This method shall be suitable for inactive cracks that are not subject to any further movement with time. In case of leaking slab, waterproofing shall be first done on top of the slab before coating the cracks to avoid ponding of water in the slab. The repair shall be undertaken as instructed by the Engineer.

Epoxy coating, made up of epoxy compounds with high strength and non-solvent two component material, is characterized by its excellent adhesion to both dry and wet concrete.

It shall be noted that epoxy coating is not a repair method, but a protective or preventive measure to prolong the bridge service life. The coating, applied using a roller brush, shall be capable of penetrating overhead, downward and vertical cracks.

10403 DEFINITION

Epoxy coating is a crack repair methodology that is applied to cracks of width up to 0.3mm.

10404 APPLICABLE STANDARDS

The epoxy material shall be in accordance with the provisions of the relevant clauses of the following Eurocode or equivalent ASTM Specification:

ASTM D2393, BS EN 1504-5	Viscosity
ASTM D7234, BS EN 1504-5	Slant Shear Bond Strength
ASTM C882, BS EN 1504-5	Slant Shear Bond Strength

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

10405 MATERIALS

1. Epoxy Sealant

Epoxy sealant shall be in accordance with the provisions of the relevant clauses of this specification and approved by the Engineer.

2. Material Use

Before using a material, it must comply with the relevant standards on type and composition.

Materials that shall be used by mixing two or more materials shall be weighed accurately at the mixing ratio indicated for that material and shall be mixed using an agitator in accordance with the manufacturer's provisions.

Materials that react and harden before their usable time (solidification time or solidification start time) shall not be used.

After confirmation of the prescribed hardening (solidification) status of the materials used in each process, the next process shall be started

10406 ORDER OF WORKS

1. Preparation of concrete surfaces

Where there are laitance, dust, oil, grease, salt or fragile areas on the concrete surface, the adhesive performance of primer of the base coat is adversely affected, these harmful materials shall be removed without fail.

Removal of laitance, adhered salts and fragile areas shall be done using a disk sander or sandblasting, and dust removal shall be efficiently done by cleaning with a compressor.

Removal of grease and oil shall be done by wiping it off with thinner. Other cleaning specifications shall apply as specified in clause 10206 of this specification.

2. Drying of concrete surface

The moisture content of the concrete surface shall be less than 8% because wet or damp concrete surfaces often adversely affect the adhesion of the primer in the base coat and cause blistering of the coating.

If the surface temperature of the concrete is above 40°C, the material applied to the surface will often foam, alter or adversely affect the surface, so the surface shall be shielded from sunlight or stop work and wait.

3. Application of Epoxy coating

The contractor shall comply with the drawings, relevant provisions and Engineer's instructions. Epoxy coating on the crack shall be carefully applied to ensure that it performs to its full potential.

4. Curing

In addition, the repair material shall be sufficiently cured and shall not be applied under construction conditions or under other conditions that may cause a reduction in strength. The provisions given in clause 10404 in this specification and the manufacturer's specifications shall be complied with.

10407 MEASUREMENT AND PAYMENT

Item: Epoxy coating on the crack

Unit: m^2

Measurement shall be in square meters of the cracks where epoxy coating is applied, as determined and approved by the engineer.

Payments shall include compensation for supplying all labour, materials, tools, equipment, and incidental items. This also includes performing all the works involved in preparing the surfaces of existing concrete and application of epoxy coating, as specified on plans and specifications, and as directed by the engineer.

10500: PATCHING/PLASTERING

10501 SCOPE OF SECTION

This section covers removal of loose debris, furnishing formwork, coating bonding agent or setting nail, patching cement mortar and curing. All repair works shall be performed in accordance with the drawings, specifications and Engineer's instructions.

10502 GENERAL

Deteriorated concrete shall be removed and the section repaired. Section repair is primarily performed to restore the cover function of the section.

The restoration material shall be integrated with the existing concrete and must have the same coefficient of thermal expansion as the concrete, low shrinkage during curing and sufficient adhesion after curing.

There are two types of patching, Type A is for defects without exposed rebars and the depth of cover exposure is up to 50mm while Type B is applied to surfaces with exposed rebars and depth of cover exposure is above 50mm.

Depending on the type of patching, location and extent of damage, the patching repairs shall be composed of either Portland cement mortars or polymer cement mortar.

10503 DEFINITION

Patching is the repair to damaged area with an approved technique and methods.

Polymer cement mortar is a type of mortar that is composed of good quality cement, properly selected aggregates and additives.

10504 APPLICABLE STANDARDS

Portland Cement Mortar shall be in accordance with the provisions of the relevant clauses of Standard Specifications for Road and Bridge Construction. The strength test for Portland cement mortar shall be based on ASTM C780 or KS EAS 18-01.

The Polymer Cement Mortar (PCM) shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent ASTM Specification:

ASTM C39, BS 6319-2	Compressive Strength
ASTM D7234, BS 6319-4	Bonding Strength to Concrete
ASTM C39, BS 6319	Bleeding Rate

The material shall be approved by the Engineer through mill certificate of the supplier.

The epoxy bonding agent to concrete surface shall be in accordance with the provisions of the relevant clauses of the following Eurocode or equivalent ASTM Specification:

ASTM D695M, BS EN 1504-5	Compressive Strength
ASTM D790M, BS EN 1504-5	Flexural Strength
ASTM D638M, BS EN 1504-5	Tensile Strength
ASTM D1002, BS EN 1504-5	Tensile Shear Bond to Steel
ASTM C882, BS EN 1504-5	Slant Shear Bond to Mortar
ASTM D7234, BS EN 1504-5	Bond Strength of Cured Concrete to Fresh Concrete

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

10506 MATERIALS

1. Portland Cement Mortar

a) Pre-mixed and pre-bagged Portland Cement Mortar

b) Water

c) Concrete Nail

d) Bonding agent to concrete (Epoxy Bonding)

2. Polymer Cement Mortar (PCM)

a) PCM powder

b) PCM Emulsion

c) Concrete Nail

d) Bonding Agent to Concrete (Epoxy Bonding)

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

10506 ORDER OF WORKS

1. Cleaning of surfaces of concrete and rebar.

Loose particles and dust shall be removed using high pressure water or vacuum cleaner. The concrete surface to be bonded must be free from dirt, oil, grease or asphalt. Corrosion shall be removed before placing the new concrete. If the deterioration is due to chloride contamination, water abrasive blasting shall be used until all the rust is removed. Other cleaning specifications shall apply as specified in clause 10206 of this specification

2. Applying Epoxy Bonding Coats to Concrete.

Epoxy bonding coats shall be applied to clean and dry concrete surfaces in order to bond firmly. Specially formulated resins shall be used for damp surfaces.

3. Placing Mortar

The mortar shall be placed in layers of about 20 mm thick. Compact each layer thoroughly over the entire surface using a wooden trowel or hammer. Generally, there should be no time delays between the placing and compacting of layers.

The patching to the surrounding concrete shall be performed using a form material, and then hammered.

4. Curing

All the patched sections shall be thoroughly and continuously cured to gain strength and to minimize drying shrinkage. Curing method shall be as per the Engineer's instructions.

10507 MEASUREMENT AND PAYMENT

Item: Patching

Unit: m^2 or m^3

Measurement shall be square meter for depth less than 50mm calculated as the area instructed by the Engineer or shall be measured by the cubic meter for depth beyond 50mm calculated as the volume, or as instructed by the Engineer.

Payment shall include full compensation for the removal of deteriorated concrete, surface cleaning and preparation, furnishing and placing of all materials, labour, equipment, tools, as well as construction and removal of formworks and other temporary works necessary to complete the patching works.

10600: REMOVAL AND DISPOSAL OF OBSTRUCTIONS FROM STRUCTURES OPENINGS

10601 SCOPE OF SECTION

This section involves removal and disposal of driftwoods, boulders, plants and any other materials around structure openings, the piers and adjacent to abutments and their disposal to a designated area.

10602 GENERAL

The Engineer shall assess the type and extent of obstructions and instruct as appropriate.

10603 DEFINITION

Obstruction refers to anything that impedes the passage of water, vehicles, people or train through a structure.

10604 APPLICABLE STANDARDS

No Standard

10605 MATERIALS

No material used

10606 ORDER OF WORKS

Boulders – Removal of boulders shall be considered as per the size of boulders blocking the opening. Considerations can be made for breakage for ease of handling and or appropriate equipment for removal.

Plants – Plants shall be cut at site and their arisings properly disposed to a designated area approved by the Engineer. No burning of plants or debris shall be permitted within the limits of the roads right of way.

Other materials – An assessment shall be made on the nature and type of other materials blocking the openings and appropriate removal mechanism device as shall apply to the material type and ease of removal.

10607 MEASUREMENT AND PAYMENT

Item: Removal of obstructions from structures openings

Unit: m^3

This work will be paid based on a unit price per cubic meter for "Removal of obstructions from structures openings", complete in place, which shall include all materials, containers, equipment, tools, labour, services of the technical service advisor, and work incidental for the Removal of obstructions from structures openings. There will be no direct payment for the cost of storage or hauling and other materials to and from the bridge or bridges, or for the containment, collection, and storage of hazardous or contaminated materials within the work areas. The cost thereof shall be deemed included in the price per cubic meter.

10700: PARTIAL REPLACEMENT OF MASONRY STONE

10701 SCOPE OF SECTION

This section covers preparation and partial replacement of masonry stone. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

10702 GENERAL

Unless otherwise stated in the special specification, it is the responsibility of the contractor to select the source of aggregate for mortar and masonry stones. The sources shall be identified prior to commencement of the contract and shall be available for inspection and sampling.

The contractor shall submit to the engineer full details of materials he proposes to use for making mortar. No mortar shall be placed in the works until the Engineer has approved the materials. Approved materials shall not thereafter be altered or substituted by other materials without the knowledge of the Engineer.

10703 DEFINITIONS

The work under this item shall consist of restoration of missing stones from masonry slope protection.

10704 APPLICABLE STANDARDS

The material shall be in accordance with the provision of the relevant clauses of the following Kenya Bureau of Standards, British Standard or equivalent Eurocode.

KS EAS 18-01	Cement
BS 812/AASHTO M6-08	Methods for determination of particle size and shape
BS 882/ BS EN 12620/BS EN 14205	Testing and Specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural sources
BS 3148/BS EN 1008/KS 2846	Water for making concrete

10705 MATERIALS

1. Stones

Stones shall be hard stones, roughly dressed square. The least dimension of any stone shall not be less than 200mm, and the volume not less than 0.01m^3. No rounded boulders shall be used.

2. Cement

Ordinary Portland Cement shall be sampled and tested in accordance with and shall comply with all the requirements of Kenya Standard KS EAS 18-01.

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk. The cement shall be protected from weather and used within specified time from date of manufacture.

3. Fine aggregates (Sand)

Fine aggregates for mortar shall be clean, hard and durable and shall be natural sand, crushed gravel sand or crushed rock sand complying with BS 882/ AASHTO M6-08. All material shall pass through a 5mm BS sieve.

Aggregates shall be delivered to site in a clean and suitable vehicle. Different types or sizes of aggregates shall not be delivered in one vehicle.

Storage of fine aggregates shall be arranged so that they can drain sufficiently before use in order to prevent fluctuations in water content of the mortar.

4. Water

Water shall be clean and free from harmful matter and shall comply with requirements of standards given in Clause 10704 of this specification.

The contractor shall carry out tests in accordance with Clause 10104 of this specification.

Seawater containing more than 1000 ppm chloride ion or 2000 ppm sulphate shall not be used for mixing or curing.

10706 ORDER OF WORKS

1. Partially or fully missing masonry stones in the damaged masonry work shall be replaced by installing new masonry stones following the alignment and dimensions indicated in the drawings.
2. All loose, imperfect or unsound masonry stones and mortar joints, panels, etc. in the existing works shall be removed. The substrata shall then be compacted to achieve a sound base to receive the new masonry stones. The slope line shall be carefully prepared and repair work shall be executed in accordance with the drawings and as per the Engineer's instructions.
3. Stones in mortared masonry work shall be laid in full bed of mortar, with joints completely filled with mortar and shove into place as applicable. Due to any reason if it becomes necessary to move or shift unit which have been already laid remove the setting mortar, then clean, and apply fresh new mortar for final placement. Coursing and mortar joints shall be done in accordance with the direction of the Engineer.
4. The laying of the stones and associated anchorage shall be in accordance with the drawings and the Engineer's instructions.
5. Where new stone masonry is placed into the existing masonry wall, joints shall be partially or completely set. Exposed surface of the existing stone masonry shall be cleaned with wire brush and lightly moistened so as to attain best possible bonding with the new work.
6. After laying of the stones into the existing masonry work, curing with water shall be done after the initial setting of the mortar at the joints, and shall be continuously cured as instructed by the Engineer.

10707 MEASUREMENT AND PAYMENT

Item: Partial Replacement of Stone Masonry

Unit: m^2

This work will be measured for payment by the actual area in square meters of partial replacement of masonry stone.

Payment shall include full compensation for provision of materials, labour, tools, equipment and other necessary accessories to complete the works.

10800: PARTIAL REPLACEMENT OF GABION WIRE MESH AND STONES

10801 SCOPE OF SECTION

This section covers preparation and partial replacement of gabion wire mesh and stones. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

10802 GENERAL

Replacement of broken gabion wires shall be done at an early stage of routine maintenance otherwise it will be more difficult to repair the damage and the risk of gabion failure will have increased.

The contractor shall carry out all the work as specified in this section unless otherwise directed by the Engineer.

10803 DEFINITIONS

This involves the restoration of damaged section of the gabion wire mesh and replacement of stones as directed by the Engineer.

10804 APPLICABLE STANDARDS

The wire mesh used for partial replacement of gabion wire mesh shall be in accordance the following British Standard, Eurocode, Kenya Bureau of standards or equivalent ASTM Specification:

BS 1052	Specification for mild steel wire for general engineering purposes
BS 443/BS EN10244-2	Testing Zinc Coatings on Steel Wire and for Quality Requirements

10805 MATERIALS

1. Wire mesh

All wire shall be to BS 1052 having a tensile strength of not less than 40kg/mm^2. The maximum mesh size shall be 100mm × 120mm. Galvanizing shall comply with the requirements of BS 443. The wire used for repair shall, unless otherwise instructed by the Engineer, be similar to the existing gabion wire.

2. Binding Wire

Binding wire shall be to BS 1052 having tensile strength of 40kg/mm^2. The wire used for binding a gabion box shall unless otherwise instructed by the Engineer comply with the provided requirement. Diameter of 2.2mm and galvanizing of 240g/m^2.

3. Infill Stones

Infill material such as stones to match the existing one unless otherwise instructed by the Engineer. The stone shall be hard, tough durable and dense, resistant to action of air and water and free from organic matter.

10806 ORDER OF WORKS

1. The contractor shall remove all the damaged wires from the gabion boxes. After removal of the damaged wires, the contractor shall fill the gabion box with appropriate material.

2. The material shall be hand packed in broken rocks of 150mm minimum dimension and 300mm maximum dimension. The sides shall be packed first using large pieces and then the internal using smaller pieces.

3. The damaged wire shall be fixed by replacing using similar wire in accordance with BS 1052, the tensile strength of the wire shall not be less than 40kg/mm^2.

4. The joints in gabion shall be stitched together with 600mm minimum lengths of binder wire, with at least one stitch per 50mm and each end of the wire shall be fixed with at least two turns upon itself.

10807 MEASUREMENT AND PAYMENT

Item: Partial replacement of gabion wire mesh and stone

Unit: m^2 and m^3

Measurement shall be based on square meters for the gabion mesh and cubic metres for the stones.

Payment shall include full compensation for provision of materials, labour, tools, equipment and other necessary accessories to complete the works.

10900: EPOXY INJECTION

10901 SCOPE OF SECTION

This section covers sealing of cracks with width greater than 0.3mm up to 3.0mm on concrete components in a bridge with an epoxy material. All repair work shall be performed in accordance with the drawings, specifications and the Engineer's instructions.

10902 GENERAL

Epoxy injection shall target repair of cracks and take into account crack size, crack width variation and depth.

Resin-based (epoxy resin) materials shall be injected into cracks; however, the adhesion of some materials is significantly reduced when injected into cracks in a wet condition compared to dry conditions.

10903 DEFINITION

This is a method of repairing non-moving cracks in concrete structures.

Epoxy resin is an adhesive material that is used to seal crack.

10904 APPLICABLE STANDARDS

The epoxy resin shall be in accordance with the provisions of the relevant clauses of the following Eurocode or equivalent ASTM Specification:

ASTM D2393, BS EN 1504-5	Viscosity
BS EN 1504-5	Pot life (60 minutes)
ASTM D792, BS EN 1504-5	Specific Gravity
ASTM D695, BS EN 1504-5	Compressive Strength
ASTM D 695M, BS EN 1504-5	Modulus of Elasticity
ASTM D790M, BS EN 1504-5	Flexural Strength
ASTM D 1002, BS EN 1504-5	Tensile Shear Bond Strength
ASTM D 7234, BS EN 1504-5	Bond Strength to Concrete (Dry/Wet)

The epoxy-based sealant material (putty) shall be in accordance with the provisions of the relevant clauses of the following Eurocode or equivalent ASTM Specification:

ASTM D792, BS EN 1504-5	Specific Gravity
ASTM D695M, BS EN 1504-5	Compressive Strength
ASTM D790M, BS EN 1504-5	Flexural Strength
ASTM D1002, BS EN 1504-5	Tensile Shear Bond Strength
ASTM D7234, BS EN 1504-5	Bond Strength to Concrete (Dry/Wet)

10905 MATERIALS

1. Epoxy Resin
2. Sealant
3. Injection Port

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

10906 ORDER OF WORKS

1. Cleaning of cracks

Loose debris such as dirt, concrete fine particles and contaminants (oil, grease, etc.) shall be marked out and removed from the cracks using high-pressure water, or special and effective solvent. Residual water or solvent in the crack shall be removed with filtered (dust and oil free) compressed air and allowed to dry.

2. Installation of Pipe Fitting

The pipe fittings shall be fixed at intervals along the length of each crack. The spacing of the pipes shall vary between 150mm to 500 mm, considering the width and depth of crack. The first and last pipe fitting shall be set at or near the bottom and top respectively.

3. Sealing of Cracks at the Surface

Using a 50mm width strap, epoxy sealant shall be applied on the area around the pipe fitting and cracks, allowing it to harden.

4. Fitting of Injector

The terminal of the injector shall be connected to the pipe fittings.

5. Injection of Epoxy

Epoxy shall be injected using air-activated epoxy injection guns. If the crack is vertical, the injection of epoxy shall commence at the lowest pipe fitting, until the epoxy exudes from the pipe fitting above. For horizontal cracks, epoxy injection shall be carried out from one end of the crack to the other or as directed by the Engineer.

6. Curing of Injected Material

After the crack has been sealed, the projecting pipe fittings shall be removed and the pipe locations shall be filled with an epoxy patching compound. Surface coating shall be applied as directed by the Engineer.

7. Performance test

Low Frequency Pulse Velocity Ultrasonic Inspection shall be carried out to determine if the epoxy resin has penetrated the full depth of the crack. If incomplete penetration is revealed by the test, such conditions shall be reworked as directed by the Engineer

10907 MEASUREMENT AND PAYMENT

Item: Epoxy injection

Unit: m

Measurement shall be in linear meters for the crack length.

Payment shall include full compensation for the removal of deteriorated concrete, surface cleaning and preparation, furnishing and placing of all materials, labour, equipment, tools, as well as construction and removal of formworks and other temporary works necessary to complete the epoxy injection.

11000: PATCHING/ SECTIONAL REPAIR

11001 SCOPE OF SECTION

This section covers patching/sectional repair which shall start with the removal of defective concrete/ or mortar, cleaning of surface of concrete and rebar and applying epoxy bonding, appropriate plaster and patching coats to concrete and rebar, placing concrete and curing. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

11002 GENERAL

Patching shall involve the replacement of damaged concrete with a new concrete cover of higher or similar strength as shall be stipulated by the standard. This shall be to localised sections.

Plastering shall involve sectional restorations where extents of damaged concrete is removed and restored on a cross section after treatment of the corroded rebar.

11003 DEFINITION

Patching is a repair method for small damaged and deteriorated areas.

Sectional repair is a repair method for larger damaged and deteriorated areas.

11004 APPLICABLE STANDARDS

Portland Cement Mortar shall be in accordance with the provisions of the relevant clauses of Standard Specifications for Road and Bridge Construction. The strength test for Portland cement mortar shall be based on ASTM C780 and/or KS EAS 10-01.

The polymer cement mortar (PCM) shall be in accordance with the provisions of the relevant clauses of the following British Standard equivalent ASTM Specification:

ASTM C39, BS 6319-2	Compressive Strength
ASTM D7234, BS 6319-4	Bonding Strength to Concrete
ASTM C39, BS 6319	Bleeding Rate

The material shall be approved by the Engineer through mill certificate of the supplier.

The epoxy bonding agent to concrete surface shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

ASTM D695M, BS EN 1504-5	Compressive Strength
ASTM D790M, BS EN 1504-5	Flexural Strength
ASTM D638M, BS EN 1504-5	Tensile Strength
ASTM D1002, BS EN 1504-5	Tensile Shear Bond to Steel
ASTM C882, BS EN 1504-5	Slant Shear Bond to Mortar
ASTM D7234, BS EN 1504-5	Bond Strength of Cured Concrete to Fresh Concrete

The material shall be approved by the Engineer through mill certificate of the supplier.

11005 MATERIALS

1. Portland cement mortar – Pre-bagged (pre-packed) materials by supplier, in case of Portland cement, mix design with admixtures (chemicals) shall be shown
2. Polymer Cement- (PCM Powder, PCM Emulsion)
3. Concrete nail
4. Bonding agent to concrete (epoxy Bonding)

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

The materials shall meet the type, strength and quality approved by the Engineer and attendant compliant certificate. The certificate shall comply with standards in clause 11005 of this specification.

11006 ORDER OF WORKS

1. Removal of defective concrete

All damaged concrete at corner edges of area to be repaired shall be removed and loose debris shall be cleaned using a wire brush.

2. Furnishing formwork

Formwork shall be provided around the damaged concrete to straighten the edges of the damaged section. The necessity of the formwork shall be instructed by the Engineer.

3. Corroded rebar treatment

Rust on the rebar shall be removed by blasting or wire brushing. After rust removal, a corrosion inhibitor shall be applied evenly to the rebar within 2 hours according to the appropriate specifications for each material.

If there is significant sectional loss of the rebar due to corrosion, the amount of rebar equivalent to the loss shall be made up. If unnecessary steel materials, such as set-up bars and steel spacers, etc., are found during construction through preliminary treatment, they shall be removed.

3. Plastering

The plastering method shall be applied to relatively small-scale sectional repairs as directed by the Engineer. Primer shall be applied with a brush and allowed to dry, a trowel or spatula shall be used to grind the mortar-like material onto the surface to be repaired, and the surface shall then be smoothed out with a plastering trowel.

In the restoration of ceiling surfaces, care shall be taken to avoid mortar separation before hardening due to the effects of its own weight and vibration, and materials such as lightweight polymer cement mortar shall be used if the effects are significant.

4. Curing

The plastered section shall be cured to develop strength and impermeability and also to minimize drying shrinkage while bond strength is developing. This shall be in accordance with the Engineer's instructions.

5. Care for works

The works shall be taken care of to discourage damage by eternal forces and vandalism.

11007 MEASUREMENT AND PAYMENT

Item: Patching / Sectional repair

Unit: m^3

Measurement shall be based on cubic meter for the volume of Patching/Sectional repair.

Payment shall include full compensation for the removal of deteriorated concrete, surface cleaning and preparation, furnishing and placing of all materials, labour, equipment, tools, as well as construction and removal of formworks and other temporary works necessary to complete the patching works.

11100: CAULKING

11101 SCOPE OF SECTION

The work in this section involves the application of sealant in a wide recess area cut along the cracks. All repair work shall be performed strictly in accordance with the drawings, specifications and Engineer's instructions.

11102 GENERAL

Caulking shall be performed as needed, and crack injection shall take into account crack size, crack width variation, and other conditions. Caulking is performed by injecting material into cracks to block ventilation and ingress of water into the concrete to prevent deterioration and corrosion of the concrete and reinforcing steel.

11103 DEFINITIONS

Caulking is a method of repair that involves treating of active cracks as movement joint by repairing them with flexible sealants.

11104 APPLICABLE STANDARDS

The epoxy grout material shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocode or equivalent ASTM Specification:

ASTM D2393, BS EN 1504-5	Viscosity
BS EN 1504-5	Pot life (60 minutes)
ASTM D792, BS EN 1504-5	Specific Gravity
ASTM D695, BS EN 1504-5	Compressive Strength
ASTM D695M, BS EN 1504-5	Modulus of Elasticity
ASTM D790M, BS EN 1504-5	Flexural Strength
ASTM D1002, BS EN 1504-5	Tensile Shear Bond Strength
ASTM D7234, BS EN 1504-5	Bond Strength to Concrete (Dry/Wet)

The material shall be approved by the Engineer through mill certificate of the supplier.

The epoxy-based sealant material shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocode or equivalent ASTM Specification:

ASTM D792, BS EN 1504-5	Specific Gravity
ASTM D695M, BS EN 1504-5	Compressive Strength
ASTM D790M, BS EN 1504-5	Flexural Strength
ASTM D1002, BS EN 1504-5	Tensile Shear Bond Strength
ASTM D7234, BS EN 1504-5	Bond Strength to Concrete (Dry/Wet)

The material shall be approved by the Engineer through mill certificate of the supplier.

Considerations for Caulking

Caulking shall be carefully applied to ensure that it performs to its full potential. In addition, the repair material shall be sufficiently cured and shall not be applied under construction conditions or under other conditions that may cause a reduction in strength. This is ensured by observing the following:

1. Safety measures for caulking materials shall be taken into consideration. Some types of materials contain solvents, and attention shall be paid to safety and sanitation (e.g., air ventilation) with respect to fire. Protective equipment shall be used when applying epoxy resins.
2. Caulking materials shall be stored in a cool, dark place out of direct sunlight, and materials past their expiration date shall not be used.
3. Attention shall be paid to the fact that the usable time varies depending on the temperature at the time of application. Material shall not be used after the usable time has elapsed.
4. For two-component type materials, the specified mixing amounts of base compound and hardener shall be observed, and mixing shall be done thoroughly using an agitator.
5. Until the caulking material develops the specified strength, proper curing shall be carried out to prevent rainwater infiltration, to control the temperature appropriately, and to prevent impact.
6. If rainwater or other water infiltration is anticipated during repair work, the work shall be stopped or covered with a sheet.
7. As a general rule, caulking materials shall be used within the temperature range of 5°C to 30°C. Since curing slows down significantly when the temperature drops (1 to 2 days curing at room temperature), appropriate measures shall be taken to maintain the required temperature when the temperature is below 5°C.
8. If the concrete surface is covered with laitance, dust, oil, grease, salt, etc., or has fragile areas, the adhesive performance of the crack sealant is often adversely affected, so these harmful materials shall be removed without fail.
9. If the concrete surface is wet or damp, the adhesive performance of the crack sealant is affected and blistering of the coating occurs; therefore, it shall be ensured that the moisture content of the concrete surface is less than 8%.
10. Before using any material, it shall be verified that the type and mix of the material satisfy the specifications.
11. After confirming the specified hardening (solidification) status of the materials used in each process, the subsequent process shall be started.

11105 MATERIALS

1. Epoxy grout
2. Sealant
3. Injection pipe

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

11106 ORDER OF WORKS

1. Cleaning of cracks.

All loose debris such as dirt, fine concrete particles and contaminants shall be removed from the crack using high-pressure water or special and effective solvent.

2. Preparation for caulking

A V-groove or a U-type groove of approximately 10mm in width and depth shall be prepared at the surface along the crack using a concrete saw, hand tools or pneumatic tools. The groove shall then be partially sealed with sealant.

3. Drilling of holes and fixing of injection pipes

Holes shall be drilled near the crack or in the groove. Injection pipes shall then be fixed at the tip of the groove at a spacing between 150 mm to 500 mm depending on the width and depth of the cracks. The spacing shall be in accordance with the drawings and/or Engineer's instructions.

4. Injecting the Epoxy Grout

Epoxy grout shall then be injected using injection pumps, or air-activated caulking guns. Duration of injection process shall be in accordance with the supplier's instructions.

5. Finishing grouting and Curing

After the crack is sealed, the projecting injection pipes shall be cut and the holes filled with epoxy patching compound. The tip of cut pipe shall be grinded to form a smooth surface.

11107 MEASUREMENT AND PAYMENT

Item: Caulking
Unit: m

Measurement shall be in linear meters.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for caulking repair as detailed in plans and specifications.

11200: CARBON FIBRE SHEET BONDING TO DECK SLAB

11201 SCOPE OF SECTION

This section covers furnishing and installation of carbon fibre sheets and adhesive resin such as epoxies to enhance load bearing capacity of concrete deck. The works involved include preparation of concrete surface, installation of carbon fibre sheet, and allowing for curing. All repair work shall be performed in accordance with the drawings, specifications, manufacturer's guideline and Engineer's instructions.

11202 GENERAL

Carbon fibre-sheet bonding is a method of restoring or improving the load-bearing capacity of concrete slabs by bonding fibre sheets mainly to the surfaces subjected to tensile and oblique tensile stresses and integrating them with the existing slabs. This method is applied for flexural and shear reinforcement of concrete bridges.

11203 DEFINITIONS

Carbon fibre sheet is a reinforced composite material in sheet form, manufactured from carbon fibre fabric infused with epoxy resins and heated to a high temperature.

The carbon fibre sheet is used to enhance the load bearing capacity of the concrete deck slab and extend its service life.

11204 APPLICABLE STANDARDS

The carbon fibre sheet shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocode or equivalent ASTM Specification:

BS 7658-1	Carbon fiber weight
ASTM D3039, BS ISO 14127:2006	Tensile Strength
ASTM D3039, BS ISO 14127:2006	Overlap Tensile Strength
ASTM D7234, BS EN 1504-5	Bond Strength to Concrete (Dry/Wet)

The epoxy adhesive shall be in accordance with the provisions of the relevant clauses of the following Eurocode or equivalent ASTM Specification:

ASTM D2393, BS EN 1504-5	Viscosity
ASTM D695M, BS EN 1504-5	Modulus of Elasticity
ASTM C882, BS EN 1504-5	Slant Shear Bond to Concrete
ASTM D7234, BS EN 1504-5	Bond Strength to Concrete (Dry/Wet)

11205 MATERIALS

1. Carbon fibre sheets.

The tensile strength and tensile modulus of elasticity of carbon fibre sheets, impregnated and cured with impregnation and adhesive resin, shall be measured according to relevant standards. The tensile strength shall be the guaranteed strength obtained from material tests (mean value of breaking strength shall be three times the standard deviation) and the tensile modulus shall be the mean value of material tests.

2. Primer.

The primer shall be a two-component epoxy resin, which shall ensure sufficient adhesion between the concrete surface and the Carbon Fibre Sheet.

The primer shall be used to ensure adhesion and integration of the concrete and carbon fibre sheet, and shall provide sufficient adhesive strength to the concrete.

3. Impregnation and adhesion resins

The resin shall be able to impregnate carbon fibres reliably and ensure Young's modulus, tensile strength, bonding strength and joint strength of the carbon fibres, and shall have a viscosity suitable for the work.

4. Surface adjustment materials

Epoxy resin-based putty shall be standard and capable of having sufficient adhesion to primers and impregnation/adhesion resins, and shall have properties suitable for the work.

5. Finishing materials.

Where protection by surface finish materials alone is deemed inappropriate, e.g., when considering collisions with travelling vehicles, special protective works shall be considered separately as directed by the Engineer.

6. Materials properties.

In order to clarify the properties of the epoxy materials, the following shall be checked:

a. Ingredients of the base and hardening materials
b. Mixing ratio (by weight)
c. Specific gravity (hardened material)
d. Viscosity (mixture)
e. Usable time (temperature rise method (250 g))

11206 ORDER OF WORKS

1. Preparation of concrete surface

Disc grinder or abrasive sandblasting shall be used to clean the concrete surface and to ensure that the surface is even and smooth. In accordance with the design documents, the bonding positions of the Carbon Fibre Sheet shall be marked on the concrete surface to ensure the straightness of the Carbon Fibre Sheet.

2. Application of epoxy primer.

Primer shall be applied to the concrete surface to improve adhesion to the carbon fibre sheet.

It shall be ensured that the concrete surface is sufficiently dry when applying the primer so that its function is not impaired. Construction shall not be carried out when the temperature is below 5°C or when the humidity is above 85%, that is, in wet weather.

However, this shall not apply if appropriate measures are taken, such as keeping the construction site warm or using a primer specifically designed for wet surfaces.

3. Adjustment of unevenness

Any unevenness on the concrete surface shall be smoothened using epoxy putty. As the flatness of the concrete surface determines the adhesion of the carbon fibre sheet, care shall be taken to ensure flattening of formwork joints and removal of air holes that may cause the sheet to lift. After the putty becomes tack-free, the surface shall be roughened with sandpaper, then cleaned.

4. Application of epoxy resin for undercoat

Using a roller, epoxy resin shall be applied to the concrete as an adhesive to bond with the CFS. It shall form a moulded composite by permeating into the CFS.

5. Installation of CFS (1st layer)

Properly aligned CFS shall be installed to the resin coated concrete surface to strengthen the section. The CFS shall be pressed using a plastic roller, starting from the centre toward the edges.

6. Squeezing out entrapped air

For complete fusion, entrapped air shall be squeezed out of the carbon sheets using a roller, before the applied adhesive sets.

7. Applying overcoat of epoxy resin

Epoxy resin shall be applied using a roller to the 1st layer of CFS as adhesive to bond to 2nd layer, and to form a moulded composite by permeating into the CFS.

8. Installing of CFS (2nd layer)

Properly aligned CFS strips (2nd layer) shall be installed to the resin over coated surface to further strengthen the section. The CFS shall be pressed using a plastic roller starting from the centre toward the edges.

9. Squeezing out entrapped air

For complete fusion, entrapped air shall be squeezed out of the carbon sheets using a roller, before the applied adhesive sets.

10. Curing and surface protection

Plastic sheeting or similar shall be used as necessary to prevent rainwater, sand, dust, etc. from adhering. For safety purposes, fire proof protection coating shall be applied to the finished surface.

11207 MEASUREMENT AND PAYMENT

Item: Carbon fibre sheet bonding to deck slab

Unit: m^2

Measurement shall be in square meters.

Payment shall be full compensation for provision for all materials, equipment, supervision, related services necessary for strengthening the concrete as detailed in plans and specifications.

11300: STEEL PLATE BONDING

11301 SCOPE OF SECTION

This Section covers the application of two different methods into the following parts: Injection method and pressure attaching method.

1. Injection method

This method covers all surface preparation, setting of steel plate on the slab, sealing of steel plate, injection of epoxy resin and curing and painting. All repair work shall be performed strictly in accordance with the drawings, specifications and Engineer's instructions.

2. Pressure attaching method

This method covers all surface preparation, application of epoxy resin, pressure attachment of steel plate and curing and painting. All repair work shall be performed strictly in accordance with the drawings, specifications and Engineer's instructions.

11302 GENERAL

This involves attachment of a steel plate on tensile stress activated surface of concrete member and injection of adhesive into the gap between steel plate and concrete member improving its load-bearing capacity.

11303 DEFINITIONS

Steel plate bonding is a technique of bonding steel plates to concrete deck slab/girder using epoxy adhesives on bridges to enhance their load-bearing capacity.

11304 APPLICABLE STANDARDS

1. Injection method

The steel plate to be used shall be in accordance with ASTM A36, BS 5950-2.

Epoxy Grout for Steel Bonding to Concrete shall be in accordance with the provisions of the relevant clauses of the following Eurocode standards or equivalent ASTM Specification:

ASTM D792, BS EN 1504-4	Specific Gravity
ASTM D2393, BS EN 1504-4	Viscosity
ASTM D790M, BS EN 1504-4	Flexural Strength
ASTM D695, BS EN 1504-4	Compressive Strength
ASTM D695M, BS EN 1504-4	Modulus of Elasticity
ASTM D 7234, BS EN 1504-4	Bond Strength to Concrete (Dry/Wet)
ASTM D1002, BS EN 1504-4	Tensile Shear Bond to Steel

The material shall be approved by the Engineer through mill certificate of the supplier.

The epoxy sealant for steel bonding to concrete shall be in accordance with the provisions of the relevant clauses of the following Eurocode or equivalent ASTM Specification:

ASTM D792, BS EN 1504-4	Specific Gravity
ASTM D790M, BS EN 1504-4	Flexural Strength
ASTM D695M, BS EN 1504-4	Compressive Yield Strength
ASTM D1002, BS EN 1504-4	Tensile Shear Bond Strength
ASTM C882, BS EN 1504-4	Slant Shear Bond to Concrete

The material shall be approved by the Engineer through mill certificate of the supplier.

The epoxy resin adhesive for steel bonding to concrete shall be in accordance with the provisions of the relevant clauses of the following Eurocode or equivalent ASTM Specification:

ASTM D792, BS EN 1504-4	Specific Gravity
ASTM D790M, BS EN 1504-4	Flexural Strength
ASTM D695M, BS EN 1504-4	Compressive strength
ASTM D638, BS EN 1504-4	Tensile Strength
ASTM D1002, BS EN 1504-4	Tensile Shear Bond Strength
ASTM D7234, BS EN 1504-4	Bond Strength to Concrete (Dry/Wet)

2. Pressure attaching method

The steel plate to be used shall be in accordance with ASTM A36, BS 5950-2.

Epoxy Grout for Steel Bonding to Concrete shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

ASTM D792, BS 5950-4	Specific Gravity
ASTM D2393, BS 5950-4	Viscosity
ASTM D790M, BS 5950-4	Flexural Strength
ASTM D695, BS 5950-4	Compressive Strength
ASTM D695M, BS 5950-4	Modulus of Elasticity
ASTM D 7234, BS 5950-4	Bond Strength to Concrete (Dry/Wet)
ASTM D1002, BS 5950-4	Tensile Shear Bond to Steel

The material shall be approved by the Engineer through mill certificate of the supplier.

The Epoxy Sealant for steel bonding to concrete shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

ASTM D792, BS 5950-4	Specific Gravity
ASTM D790M, BS 5950-4	Flexural Strength
ASTM D695M, BS 5950-4	Compressive Yield Strength

ASTM D1002, BS 5950-4	Tensile Shear Bond Strength
ASTM C882, BS 5950-4	Slant Shear Bond to Concrete

The material shall be approved by the Engineer through mill certificate of the supplier.

The epoxy resin adhesive for steel bonding to concrete shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

ASTM D792, BS 5950-4	Specific Gravity
ASTM D790M, BS 5950-4	Flexural Strength
ASTM D695M, BS 5950-4	Compressive strength
ASTM D638, BS 5950-4	Tensile Strength
ASTM D1002, BS 5950-4	Tensile Shear Bond Strength
ASTM D7234, BS 5950-4	Bond Strength to Concrete (Dry/Wet)

The material shall be approved by the Engineer through mill certificate of the supplier.

11305 MATERIALS

a. Steel Plate

b. Primer (Epoxy Base)

c. Epoxy Resin Adhesive for Injection

d. Epoxy Sealant

e. Anchor Bolts

f. Wood and angle for fitting

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

11306 ORDER OF WORKS

1 Injection Method

a) Surface preparation

The bottom surface of slab to be bonded with steel plate shall be cleaned, the steel surface shall be completely free from any mill scale, rust, grease or other contaminants. Surface irregularities shall be levelled using a disc grinder. A primer which is compatible with the adhesive shall then be applied on the surface.

b) Setting of Steel Plate on the Slab

Injection pipes shall be attached to the steel plates and anchor bolts provided to temporarily support steel plates (placed below the slab surface with an average gap of 5 mm) in the event that the deck slab settles. Joints between steel plates shall be welded at site.

c) Sealing of steel plate

The periphery of the steel plate shall be sealed with epoxy putty as well as the area surrounding the injection holes.

d) Injection of epoxy resin

Mixing shall be continuously done during the injection. The epoxy grout shall be injected through injection pipes to fill the gap between the plate and concrete.

e) Curing and painting

A suitable chamfer/fillet shall be formed in the adhesive around the edge of the plates and the concrete surfaces. Steel plates and all its components shall be adequately painted for corrosion protection.

2 Pressure attaching method

a) Surface preparation

The bottom surface of slab/girder to be bonded with steel plate shall be cleaned, the steel surface shall be free from any mill scale, rust, grease or other contaminants. Surface irregularities shall be levelled using a disc grinder. A primer which is compatible with the adhesive shall be applied on the surface.

b) Application of Epoxy Resin

The adhesive shall be thicker along the centre of the steel plate than at the sides. Plastic spacers shall be used to maintain the minimum adhesive thickness of 1- 2 mm.

c) Pressure attachment of steel plate

The epoxy resin adhesive shall be applied to the steel plate which shall be set at the required position of the deck slab/girder, and pressed using the anchor bolts wedging off with the temporary stiff wood and angular.

d) Curing and Painting

A suitable chamfer/fillet shall be formed in the adhesive around the edges of the plate and concrete surface. Steel plates and all its components shall be adequately painted for corrosion protection.

11307 MEASUREMENT AND PAYMENT

Section: Steel bonding plate

Unit: m^2

Measurement shall be in square metres.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for strengthening the concrete as detailed in plans and specifications.

11400: PARTIAL DECK REPLACEMENT

11401 SCOPE OF SECTION

This section covers all support of existing structures, removal of defective deck slab concrete, preparation of old concrete and rebar, setting of formworks, cutting of existing rebar and addition of new rebar, casting and curing of concrete and removal of formworks. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

11402 GENERAL

Partial deck slab replacement includes complete removal of defective concrete and its adjacent surfaces to its full depth, setting formworks, cleaning the existing rebar (and additional rebar, if required) and casting of new concrete. The extent of repair shall be determined by the engineer.

11403 DEFINITIONS

Partial replacement of deck slab is carried out to replace a portion of the concrete slab that has been severely damaged or deteriorated.

11404 APPLICABLE STANDARDS

BS EN 1992-1-1:2004+A1:2014	Design of concrete structures
ACI 318 - 56	Reinforced concrete design for structural concrete

11405 MATERIALS

1. Portland Cement
2. Water
3. Aggregates
4. Silica Fume
5. Rebar (Reinforcing bar, use Grade 40 for 16mm diameter)
6. Epoxy Resin (Bonding Coat to Concrete)
7. Anti-Corrosion Primer (Bonding Coat to Rebar)

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

11406 ORDER OF WORKS

1. Support of existing Structure

The existing structure shall be properly supported to safeguard it against instability and deformation during the repair work.

2. Removal of concrete

All deteriorated or damaged concrete surface shall be cut using a saw, forming vertical edges, and then removed using a breaker and a chisel. Rebar shall be examined for loss of section due to corrosion. If the cross sectional area of the reinforcement has reduced by more than 20%, additional reinforcement shall be required.

Special considerations shall be made where concrete is to be broken around shear studs. This shall be directed by the Engineer.

3. Preparation of Old Concrete and Rebar

A suitable bonding agent for concrete and reinforcement shall be applied to the concrete.

4. Setting of Formworks

Soffit formwork for re-casting deck slab shall be rigid and well-supported to prevent the new concrete from sagging due to its own weight.

5. Cutting of Existing Rebar and Addition of New Rebar

Deteriorated old rebar shall be cut up to the required lap length. New bars to be provided shall be in accordance with the drawings and Engineer's instructions.

Rust shall be removed from the rebars by blasting or wire brushing.

Corrosion inhibitor shall then be evenly applied to the rebar within 2 hours in accordance with the specifications for each material. If there is significant sectional loss of the rebar due to corrosion, the amount of rebar equivalent to the loss shall be made up. If unnecessary steel materials, such as set-up bars and steel spacers are found during construction through preliminary treatment, they shall be removed.

Any damage to the rebar to remain in place shall be repaired or replaced to the satisfaction of the Engineer at the Contractor's expense. All existing rebar shall remain in place except those which are significantly corroded.

Tying of loose bars shall be done as per the Engineer's instructions. Rebar which has been cut or have lost 20% or more of their original cross-sectional area shall be supplemented with new reinforcing bars.

The new bars shall be lapped to the existing bars as per the drawings, specifications and Engineer's instructions, which shall be coated with zinc-rich primer. An approved mechanical bar splice capable of developing tension of at least 125% of the yield strength of the existing bar shall be used when it is not feasible to provide the minimum bar lap.

6. Concrete mix

The concrete mix used shall be capable of producing highly impermeable concrete with adequate workability and low shrinkage. The repair mix shall be ideally made with the same type of aggregate as the original concrete to minimize thermal stress. It shall be necessary to use a 20mm maximum aggregate size for repairs because the space for placing concrete is often restricted. Care shall be taken to ensure concrete is not poured from a height more than 1.5m and that it is adequately vibrated. Care shall be taken to ensure that aggregate do not react with alkali from the cement particularly where rich mix shall be used.

The water cement ratio shall not exceed 0.4 to minimize stresses caused by drying shrinkage. In some situations, it shall be helpful to add shrinkage-compensating admixtures to the mix to offset shrinkage and thermal contraction.

The fresh concrete shall have high cement-paste content for proper bonding with the old concrete and reinforcement. It should also provide high alkalinity for the protection of steel. The mix shall have a minimum cement content of 410 kg/m^3 of concrete. The grading of aggregate and sand shall be properly selected to produce a dense concrete and to keep bleeding to an absolute minimum, especially for soffit repairs where bleeding can lead to complete separation between old and new concrete.

7. Concrete placement

Concrete shall be placed in the soffit formworks through a suitable method and compacted well using internal or external vibrators. Unformed surfaces shall be finished by broom, wood float, or steel trowel to match the adjacent existing concrete approved by the Engineer.

8. Curing and removal of formwork

Continuous water curing with wetted cotton mat shall be to slow down drying. Formworks for load bearing structural members shall remain in position until at least 80% of the 28 days compressive strength of the new concrete is achieved.

11407 MEASUREMENT AND PAYMENT

Item: Partial deck slab replacement

Unit: m^3 for concrete, tonnage for steel and m^2 for formwork

Partial deck slab replacement performed in accordance with the plans and specifications will be measured in cubic meters. The quantity to be paid for includes the replaced concrete on the deck.

Payment shall include full compensation for the replaced concrete on the deck, provision of materials, labour, tools, equipment and other necessary accessories to complete the work.

11500: WATER PROOFING ON DECK SLAB

11501 SCOPE OF SECTION

This section covers the application of two methods of water proofing to the deck slab as below:

1. Rubberized membrane method

This section covers preparation of deck surface, primer, base coat, inter-coat, top coat, tack coat and asphalt pavement. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

2. Asphalt compound method

This section covers preparation of deck surface, primer coating, melting asphalt compound, application of asphalt compound, application of silica sand for protection, curing and asphalt pavement. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

11502 GENERAL

Waterproofing on deck slab refers to the installation of a waterproof layer on existing concrete slabs to prevent water ingress into the slab.

11503 DEFINITIONS

Concrete water proofing is the application of impervious material layer on concrete which prevents water from penetrating and making the structure water proof so that it remains relatively unaffected by water.

11504 APPLICABLE STANDARDS

1. Rubberized membrane method

Waterproofing by rubberized membrane shall be in accordance with the provisions of the relevant clauses of the following Eurocode or equivalent ASTM Specification:

ASTM D638, BS EN 12311-2	Elongation
ASTM D638, BS EN 12311-2	Tensile Strength
ATMS D882	Concrete Bond Strength

The material shall be approved by the Engineer through manufacture's certificate.

2. Asphalt compound method

Waterproofing by asphalt compound membrane shall be in accordance with the provisions of the relevant clauses of the following Eurocode or equivalent ASTM Specification:

ASTM D217, BS EN 1426:2005	Penetration with Conic Needle
ASTM D3461, BS EN 1110:2010	Melting Temperature
ASTM D638, BS EN 12311-2	Elongation
ASTM D638, BS EN 12311-2	Tensile Strength

The material shall be approved by the Engineer through manufacturers certificate of the supplier.

11505 MATERIALS

1. Rubberized membrane method
   a. Primer
   b. Rubberized Membrane (2nd layer ~ 4th layer)
   c. Tack Coat (Finish Coat)

   The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

2. Asphalt compound method
   a) Primer
   b) Asphalt Compound Membrane
   c) Silica sand No.4

   The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

11506 ORDER OF WORKS

Rubberized Membrane Method

1. Preparation of deck surface

Deformation of the slab and cover surfaces shall significantly affect the performance of the waterproofing layer, and therefore the slab and cover surfaces on which the waterproofing layer is to be applied shall be sound and smooth and free from deformation.

a) Care shall be taken when cutting existing pavements in order not to damage the existing slab surface.

b) Tack coat and other fragile parts of the surface remaining after removal of the existing pavement shall be properly removed and repaired.

2. 1st Layer (Primer)

Primer coat shall be applied once or twice on the cleaned substrate using a roller brush. The coating shall be approximately 0.2 kg/m^2 and naturally dried for more than 30 minutes until tack-free as per the manufacture's instructions.

3. 2nd Layer (Base coat)

Base coat as 2nd layer is a rubberized membrane which shall be applied on the primer using a roller brush, to form a uniform film with consistent thickness. Application rate of 0.4 kg/m^2.

4. *3rd Layer (Intermediary coat)*

   Intermediary coat, the 3rd layer, is a rubberized membrane which shall be applied on the base coat using roller brush, to form a uniform film with equal thickness. Application rate of 0.4 kg/m^2.

5. *4th Layer (Top coat).*

   Top Coat, the 4th layer, is a rubberized membrane which shall be applied on the intermediary coat using roller brush to form a uniform film with equal thickness. Application rate of 0.4 kg/m^2.

6. *5th Layer (Tack coat).*

   Tack Coat, 5th layer, is an asphalt base coating which shall be applied on the top coat using a roller brush, for better bonding to asphalt pavement. Application rate of 0.1 kg/m^2.

7. *Waterproof layer*

   The waterproofing layer shall be applied after the tack coat is cured in accordance with the drawings, specifications and Engineer's instructions.

8. *Paving*

   The pavement shall be constructed in accordance with section 5700 of the Specifications for Road and Bridge Construction.

Asphalt Compound Method

1. *Surface preparation*

   Existing asphalt pavement shall be stripped off and removed. The deck surface shall be cleaned using a wire brush, removing oil, asphalt and concrete chips and dust that will affect adhesion to the substrate. The substrate shall be kept dry during the waterproofing works.

2. *Primer coating*

   Primer coat shall be applied in accordance with the Engineer's instructions on the cleaned substrate using a roller brush. The coating shall be applied at a rate of 0.2 kg/m^2 and naturally dried for more than 30 minutes until tack-free as per the manufacture's instructions.

3. *Melting asphalt compound*

   Asphalt membrane shall be melted in the mechanically agitated heating process and mixed in a kettle. This unit shall keep the contents continuously agitated until the material is lump free and can flow freely from the mixing unit, at a temperature recommended by the manufacturer.

4. *Application of asphalt compound*

The asphalt membrane shall be applied at a rate of 0.7 kg/m^2 using a rubber brush within the temperature range recommended by the manufacturer, to the clean, primer-coated concrete deck, forming a uniform film with equal thickness. The laying operation shall eliminate discontinuities in the membrane.

5. *Application of silica sand for protection*

Silica sand shall be scattered on the waterproofing layer while the membrane is still hot. The silica sand shall be applied at rate of 3.0 kg/m^2 in accordance to the manufacture's instructions.

6. *Curing and paving*

Curing shall be carried out until waterproofing membrane is cooled down to normal temperature. The excess silica sand shall be removed using a broom.

Asphalt overlay shall then be applied in accordance with section 5700 of the Specifications for Road and Bridge Construction.

11507 MEASUREMENT AND PAYMENT

Rubberized membrane method

Item: Waterproofing on deck slab (Rubberized membrane method)

Unit: m^2

Waterproofing works should be measured and paid per square meter computed as the product of length and width of the section works have been executed. The rate should include for preparation works including cleaning and application of the primer coat.

Asphalt compound method

Item: Waterproofing on deck slab (Asphalt compound method)

Unit: m^2

Waterproofing works should be measured and paid per square meter computed as the product of length and width of the section works have been executed. The rate should include for preparation works including cleaning and application of the primer coat.

11600: FAST SETTING CONCRETE FOR CONTINUED DECK SLAB

11601 SCOPE OF SECTION

This section covers removal of deck slab concrete, setting of formworks, addition of rebars, clean up, application of epoxy resin to existing concrete surface for proper bonding to fast-setting concrete, mixing, pouring, finishing of surface and curing. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

11602 GENERAL

The works include removal of defective concrete, and its adjacent surfaces to its full depth, and replace with fast setting concrete.

11603 DEFINITIONS

Fast setting concrete is a rapid set concrete that is a blend of ordinary and specialist cements, high quality graded aggregates and a combination of polymers and admixtures.

11604 APPLICABLE STANDARDS

Fast setting mortar shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocode or equivalent ASTM Specification:

ASTM C39, BS 7533	Compressive Strength
ASTM C827, BS 7533	Expansion Rate
ASTM C940, BS 7533	Bleeding Rate
BS EN 1015	Consistency (6~10 sec)

Consistency shall be checked by funnel test (bottom inner diameter: 14mm, upper inner diameter: 70mm, height: 392mm, volume: 630ml), if materials shall be applied by hydraulic pump. The material shall be approved by the Engineer through mill certificate of the supplier.

11605 MATERIALS

1. Cement
2. Aggregates
3. Rapid hardener admixture
4. Clean water
5. Epoxy Resin (Bonding Coat to Concrete)
6. Special anti-corrosion Primer (Bonding Coat to Rebar)

Concrete shall meet the quality specifications below:

Compressive strength (N/mm^2) at 3 hours	Maximum size of coarse aggregate (mm)	Slump range (cm)
24	25	10 - 14

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

11606 ORDER OF WORKS

1 Removal of defective deck slab concrete

Defective concrete surface shall be cut using a saw, forming vertical edges, and then removed using a breaker and a chisel. Rebars shall be examined for loss of section due to corrosion. If cross sectional area of the reinforcement has reduced by more than 20%, additional reinforcement shall be required.

2. Setting of formworks

Soffit formwork for re-casting deck slab shall be rigid and well-supported to prevent the fast-setting concrete from sagging due to its own weight.

3. Addition of longitudinal/Transverse rebar

Longitudinal and transverse rebar to be provided shall be of same or bigger diameter than the existing rebar and should also consider the current loading condition.

Spacing of rebar shall be less than 150mm for durability and to avoid occurrence of bending cracks. Length of rebar shall be around 1.4m for sufficient connection of each deck slab or as per the Engineer's instructions.

Additional rebar of transverse direction shall be connected by rebar coupler. The end of the transverse rebar shall be threaded for connection of coupler. The new rebar shall be tied to the existing bars using tie wires or by welding or as directed by the Engineer.

4. Clean up inside formwork

The inner side of the formwork shall be cleaned after placement of the additional rebars and formwork is completed.

5. Apply Epoxy Resin to Existing Concrete Surface for Proper Bonding to Fast-setting Concrete

Epoxy resin shall be applied for all exposed section of existing concrete. Fast-setting concrete shall be poured within hardening time of epoxy resin.

6. Wet the Formwork

After cleaning inside formwork, water shall be sprinkled to keep wet condition prior to placing concrete.

7. Mix with water

The fast-setting concrete shall be mixed in accordance with the manufacturer's instructions.

8. Pour from lower side to upper position

Concrete shall be placed in the soffit formworks through a suitable method and compacted well using internal or external vibrators in accordance with the Engineer's instructions.

8. Finishing of surface.

After placing 1m length of fast-setting concrete, finishing of the surface shall be started. Finishing of unformed surfaces shall be done by broom, wood float, or steel trowel to match the adjacent existing concrete.

9. Curing

Continuous curing shall be carried out after 4 hours of placing.

11607 MEASUREMENT AND PAYMENT

Item: Fast setting concrete for continued deck slab

Unit: m^3

Measurement shall be based on cubic meters.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for provision of fast setting mortar for continued deck slab as detailed in plans and specifications.

11700: PROTECTIVE MORTAR

11701 SCOPE OF SECTION

This section covers repair work in accordance with specifications and as instructed by the Engineer. It entails; surface preparation, application of Polymer Cement Mortar (PCM), lithium nitrite, emulsion, mixing and curing.

11702 GENERAL

The protective mortar enhances cover on the concrete surface to inhibit the ingress of water, oxygen, chloride ions, salt attack and carbon dioxide, which causes deterioration in concrete.

11703 DEFINITIONS

Protective mortar is a product of polymer cement and lithium nitrate content which is effective against chloride ions.

11704 APPLICABLE STANDARDS

The protective mortar by polymer cement mortar with lithium nitrite shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent ASTM Specification:

ASTM C39, BS 6319	Compressive Strength
BS 6319	Bonding strength to concrete (2.0 N/mm^2 (wet condition))
ASTM C940, BS 6319	Bleeding Rate
BS 6319	Consistency (6~10 sec)
BS 6319	Finishing appearance (Homogeneous appearance)
BS 6319	Workability (No hanging, shearing, peeling- off and bulging)

11705 MATERIALS

1. Polymer cement powder with lithium nitrite
2. Emulsion made of lithium nitrite and adhesive

The materials shall be in accordance with the provisions in the specifications and approved by the Engineer.

11706 ORDER OF WORKS

1. Preparation of concrete surfaces

The removal of laitance, adhered salts and fragile areas shall be done using a disk sander or sandblasting, dust removal shall be done by cleaning with a compressor, and grease and oil shall be wiped off with thinner.

2. Drying of concrete surface

The moisture content of the concrete surface shall be less than 8% because wetness affect adhesion.

The surface shall be shielded from sunlight or the work shall be stopped if the surface temperature of the concrete is above 40°C. This shall be done to minimize foaming of material.

3. Material mixing

Materials type and composition shall be in accordance with the specifications.

Materials that are used by mixing two or more materials shall be weighed accurately at the mixing ratio indicated for that material and mixed using an agitator.

Materials that react and harden (solidify) and exceed their usable time (solidification time or solidification start time) shall not be used.

The amount of material used shall satisfy the standard usage volume.

After confirming the prescribed hardening (solidification) status of the materials used in each process, the following process shall be started.

4. Application of PCM

The PCM with Lithium Nitrite shall be applied and spread on the surface to be patched using trowel and/or brush.

5. Curing

Water shall be sprayed on patched surface for 3 days continuously.

11707 MEASUREMENT AND PAYMENT

Item: Protective mortar

Unit: m^2

Measurement and payment for application of protective mortar should be per square meter being the product of the length and width of the section where work is executed. The rate should be inclusive of surface preparation.

11800: PROTECTIVE COATING

11801 SCOPE OF SECTION

This section covers surface preparation, mixing acryl urethane protective coating materials and application of protective coating. The repair work shall be carried out in accordance with the specifications and as directed by the Engineer.

11802 GENERAL

The purpose of the protective coating is to cover the concrete surface with a coating to inhibit the penetration of water, oxygen, chloride ions and carbon dioxide, which are factors in concrete deterioration. A protective coating may be metallic or non-metallic. Commonly used materials in non-metallic protective coatings include polymers, epoxies and polyurethanes. Materials used for metallic protective coatings include zinc, aluminum and chromium.

11803 DEFINITIONS

A protective coating is a layer of material applied to the surface of another material with the intent of inhibiting or preventing ingress of substances.

11804 APPLICABLE STANDARDS

The acryl urethane protective coating shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent ASTM Specification:

ASTM D3359, ASTM D7234, BS 5493:1977	Bond Strength
ASTM D6943, BS 5493:1977	Tap Water Resistance
ASTM D6943, BS 5493:1977	Acid Resistance (5% H_2SO_4)
ASTM D6943, BS 5493:1977	Alkali Resistance (5% NaOH)

11805 MATERIALS

1. Base Resin
2. Hardener

The materials shall be in accordance with the provisions in the specifications and approved by the Engineer.

11806 ORDER OF WORKS

1. Preparation of concrete surfaces

The removal of laitance, adhered salts and fragile areas shall be done using a disk sander or sandblasting, dust removal shall be done by cleaning with a compressor, and grease and oil shall be wiped off with thinner.

2. Drying of concrete surface

The moisture content of the concrete surface shall be less than 8% because wetness affect adhesion.

The surface shall be shielded from sunlight or the work shall be stopped if the surface temperature of the concrete is above 40°C. This shall be done to minimize foaming of material.

3. Mixing acryl urethane protective coating materials

The Base Resin and Hardener shall be mixed at a ratio by weight of 4:1, respectively.

4. Application of protective coating

Acryl Urethane Protective Coating shall be applied using a roller and/or brush on the surface to be coated. Interval time between application of first layer and second layer is minimum 3 hours for next coating. Coating is normally applied for 1 to 3 coats shall be applied.

11807 MEASUREMENT AND PAYMENT

Item: Protective coating

Unit: m^2

Measurement shall be in square meters.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for provision of protective coating as detailed in plans and specifications.

1900: RECASTING CONCRETE/GROUT

11901 SCOPE OF SECTION

This section covers removal of deteriorated girder concrete, preparation of concrete surface and rebar, cutting of deteriorated rebar and adding new rebar, setting formworks, mixing of mortar, mortar grouting, curing and removal of formworks.

11902 GENERAL

Deteriorated or damaged concrete shall be removed and restored. Restoration is performed to reinstate the cover function of the cross section after treatment with corroded rebar.

11903 DEFINITIONS

Recasting method involves casting of the damaged area, by placing concrete or grouting mortar on the formwork.

11904 APPLICABLE STANDARDS-

The epoxy bonding primer to concrete/grout shall be in accordance with the provisions of the relevant clauses of the following Eurocodes or equivalent ASTM Specification:

ASTM D695M, BS EN 1504-5	Compressive Strength
ASTM D790M, BS EN 1504-5	Flexural Strength
ASTM D638M, BS EN 1504-5	Tensile Strength
ASTM D1002, BS EN 1504-5	Tensile Shear Bond to Steel
ASTM C882, BS EN 1504-5	Slant Shear Bond to Mortar

The zinc-rich primer applied to rebar shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

ASTM D523, BS EN ISO 2063-1	Gloss@60 Angle
ASTM D3359, BS EN ISO 2063-1	Adhesion
ASTM D117, BS EN ISO 2063-1	Salt Spray Resistance
BS EN ISO 2063-1	%Zinc by Weight in Dried Film Test (87.5±2 %)

11905 MATERIALS

1. Concrete - Cement, Sand and Aggregates,
2. Admixtures for consistency
3. Reinforcing steel bars
4. Bonding coat
5. Anti-Corrosion Primer

The materials shall be in accordance with the provisions in the specifications and approved by the Engineer.

11906 ORDER OF WORKS

1. Removal of old concrete

All deteriorated or damaged concrete shall be removed to form the vertical edges using a breaker and chisel. Rebars shall be examined for any loss of section due to corrosion. If cross sectional area of the reinforcement has been reduced by more than 20%, extra reinforcements shall be provided as per the Engineer's instructions.

2. Cutting of deteriorated rebar and adding new rebar

Deteriorated old rebars shall be cut up to the required lap length. New bars to be provided shall be of same or bigger diameter than the existing, taking into consideration the existing loading condition of the structure. The lap length shall be calculated as 50 times the new rebar diameter. The new rebar shall then be tied to the existing bars using tie wires or by welding in accordance with the Engineer's instructions.

3. Preparation of old concrete and rebar

A suitable bonding agent for concrete and reinforcement shall be selected taking into consideration limited working time available for fixing the formwork and placing the new concrete. Concrete should be placed immediately after applying bonding coat to the faces of old concrete and anti-corrosion primer to rebars.

4. Setting formworks

Formwork for re-casting the girder shall be rigid and well-supported to prevent the new concrete from sagging to the old concrete due to its own weight.

5. Mixing of mortar

Mixing of cement mortar shall be as directed by the Engineer.

6. Mortar grouting

The mortar shall be carefully placed to avoid the entrapment of air. When pumping is used, the delivery horse shall be at a low position while pouring, to allow the air to be displaced.

7. Curing and removal of formworks

Continuous water curing by spraying shall be applied to help slow down drying process.

Formworks for load bearing structural members shall remain in position until at least 80% of the 28 days compressive strength of the new concrete is achieved.

11907 MEASUREMENT AND PAYMENT

Item: Recasting concrete / grout

Unit: Ton, m^3 and m^2

Measurements shall be in tonnes of steel, cubic meters of concrete and square meters of formwork used.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for recasting concrete as detailed in plans and specifications.

12000: CARBON FIBRE SHEET/ PLATE BONDING TO CONCRETE GIRDER

12001 SCOPE OF SECTION

This section covers preparation of concrete, application of primer, adjustment of unevenness with putty, application of epoxy resin for undercoat, installation of carbon fibre sheet/plates, squeezing out entrapped air, coating resin application and surface protection. All repair works shall be in accordance with the drawings, specifications and Engineer's instructions.

12002 GENERAL

Since carbon fibre plates possess a high tensile strength and proper module of elasticity, it is considered as a suitable alternative to strengthen girders. In this repair method, a carbon fibre plate is used to strengthen a girder increasing its ultimate load bearing capacity and serviceability.

The carbon fibre sheet/plate bonding to concrete girder is a method of restoring or improving the load-bearing capacity of concrete girders by bonding fibre sheets/plates mainly to the surfaces subjected to tensile and oblique tensile stresses and integrating them with the existing girders. This method is applied to flexural and shear reinforcement of concrete bridges.

12003 DEFINITIONS

Carbon fibre is a weaved mat of fibers that when impregnated and cured with resin, creates a material that is light and strong.

Carbon fibre sheet is a sheet made of carbon fibre.

12004 APPLICABLE STANDARDS

1. Carbon fibre sheet

The carbon fibre sheet shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocodes or equivalent ASTM Specification:

BS 7658-1	Carbon fiber sheet weight
ASTM D3039, BS ISO 14127:2008	Tensile Strength
ASTM D3039, BS ISO 14127:2008	Overlap Tensile Strength
ASTM D7234, BS ISO 14127:2008	Tensile Bond Strength to Concrete (Dry/Wet)

The epoxy adhesive for bonding carbon fibre sheet shall be in accordance with the provisions of the relevant clauses of the following Eurocodes or equivalent ASTM Specification:

ASTM D2393, BS EN 1504-4	Viscosity
ASTM D638M, BS EN 1504-4	Tensile Strength
ASTM D790M, BS EN 1504-4	Flexural Strength
ASTM D695M, BS EN 1504-4	Compressive Strength
ASTM D695M, BS EN 1504-4	Modulus of Elasticity
ASTM C882, BS EN 1504-4	Slant Shear Bond to Concrete
ASTM D7234, BS EN 1504-4	Adhesive Strength (Dry/Wet)

The material shall be approved by the Engineer through mill certificate of the supplier.

2. Carbon fibre plate

The carbon fibre plate shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

BS 7658-1	Carbon fiber plate weight
ASTM D3039, BS ISO 14127:2008	Tensile Strength
ASTM D7234, BS EN 1504-4	Bond Strength to Concrete

The material test shall be applied tensile strength test for carbon fibre plate to be approved by the Engineer.

The epoxy adhesive for bonding carbon fibre plate shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

ASTM D792, BS EN 1504-4	Specific Gravity
ASTM D790M, BS EN 1504-4	Flexural Strength
ASTM D695M, BS EN 1504-4	Compressive Strength
ASTM D695M, BS EN 1504-4	Modulus of Elasticity
ASTM D638M, BS EN 1504-4	Tensile Strength
ASTM D1002, BS EN 1504-4	Tensile Shear Bond
ASTM D7234, BS EN 1504-4	Bond Strength to carbon fiber plate & Concrete

The material shall be approved by the Engineer through mill certificate of the supplier.

12005 MATERIALS

1. Carbon fibre sheet method

a) Carbon fibre sheet

b) Carbon fiber sheet strip

c) Epoxy primer

d) Epoxy putty

e) Epoxy resin

2. Carbon fibre plate method

a) Carbon fibre plate

b) Epoxy primer

c) Epoxy putty

d) Epoxy resin

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

12006 ORDER OF WORKS

Carbon Fibre Sheet Method

1. Preparation of concrete surface

The Disc grinder or abrasive sandblasting shall be used to clean the concrete surface and to ensure that the surface is even and smooth. The bonding positions of the Carbon Fibre Sheet shall be marked on the concrete surface in accordance with the drawings to ensure the straightness of the Carbon Fibre Sheet.

2. Application of epoxy primer

Primer shall be applied to the concrete surface as a strengthening of the existing concrete surface and to improve adhesion to the carbon fibre sheet. The primer shall be applied on a dry concrete surface. The primer shall not be applied when temperature is below 5°C or when the humidity is above 85%, (in the other sections, we restricted to moisture of 8%, not humidity) e.g., in wet weather.

3. Adjustment of unevenness

Any unevenness on the concrete surface shall be smoothened using epoxy putty. As the flatness of the concrete surface determines the adhesion of the carbon fibre sheet, care shall be taken to ensure flattening of formwork joints and removal of air holes that cause the sheet to lift. After the putty becomes tack-free, the surface shall be roughened with sandpaper, then cleaned.

4. Application of epoxy resin for undercoat

Using roller, epoxy resin shall be applied to the concrete as an adhesive to bond with the CFS. It shall form a moulded composite by permeating into the CFS.

5. Installation of CFS (1st layer)

Properly aligned CFS shall be installed to the resin coated concrete surface to strengthen the section. The CFS shall then be pressed using deformed roller, starting from the centre toward the edges.

6. Squeezing out entrapped air

For complete fusion, the entrapped air shall be squeezed out of the carbon sheets using a roller before the applied adhesive sets.

7. Applying overcoat of epoxy resin

Epoxy resin shall be applied using a roller to the 1st layer of CFS as adhesive to bond to 2nd layer, and to form a moulded composite by permeating into the CFS.

8. *Installing of CFS (2nd layer)*

   Properly aligned CFS strips (2nd layer) shall be installed to the resin over coated surface to further strengthen the section. The CFS shall be pressed using a deformed roller starting from the center toward the edges.

9. *Squeezing out entrapped air*

   For complete fusion, the entrapped air shall be squeezed out of the carbon sheets using a roller before the applied adhesive sets.

10. *Curing and surface protection*

    When curing, plastic sheeting or similar shall be used to prevent rainwater, sand, dust, etc. from adhering. For safety purposes, fire proof protection coating may be applied to the finished surface.

Carbon fibre plate method

1. *Preparation of surface*

   The Disc grinder or abrasive sandblasting shall be used to clean the concrete surface and to ensure that the surface is even and smooth. The bonding positions of the Carbon Fibre Plate shall be marked on the concrete surface in accordance with the drawings to ensure the straightness of the Carbon Fibre Plate.

2. *Application of epoxy primer*

   Primer shall be applied to the concrete surface as a strengthening of the existing concrete surface and to improve adhesion to the carbon fibre sheet. The primer shall be applied on a dry concrete surface. The primer shall not be applied when temperature is below 5°C or when the humidity is above 85%.

3. *Adjustment of unevenness*

   Any unevenness on the concrete surface shall be smoothened using epoxy putty. As the flatness of the concrete surface determines the adhesion of the carbon fibre sheet, care shall be taken to ensure flattening of formwork joints and removal of air holes that cause the sheet to lift. After the putty becomes tack-free, the surface shall be roughened with sandpaper, then cleaned.

4. *Application of epoxy resin for undercoat*

   Using roller, epoxy resin shall be applied to the concrete as an adhesive to bond with the CFP. It shall form a moulded composite by permeating into the CFP.

5. *Installation of Carbon Fibre Plate (CFP)*

   Properly aligned CFP shall be installed longitudinally to the adhesive coated concrete surface.

6. Squeezing out entrapped air

For complete fusion, entrapped air shall be squeezed out of the carbon fibre plates using a roller, before the applied adhesive sets.

7. Pressure attachment of CFP

The CFP shall be set at a position and pressed using a wooden anchor frame and set bolts for curing.

12007 MEASUREMENT AND PAYMENT

Item: Carbon fibre sheet/ plate bonding to concrete girder

Unit: m^2

Measurements shall be in square metres.

Payment shall include full compensation for provision of materials, labour, tools, equipment and personnel man-hours for the completion of the works.

12100: JACKETTING WITH CONCRETE

12101 SCOPE OF SECTION

This section covers the strengthening vertical members by removal of deteriorated concrete, addition of rebar, setting up formworks, placing and curing of concrete. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

12102 GENERAL

Jacketing with concrete is applied to substructures that have deteriorated or need strengthening.

12103 DEFINITIONS

Jacketing is a method of structural retrofitting and strengthening that involves addition of longitudinal and transverse reinforcement around the existing substructures and application of a concrete cover.

It is used to increase load bearing capacity following a modification of the structural design or to restore structural design integrity due to a failure in the structural member.

12104 APPLICABLE STANDARDS

The jacketing with concrete shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocodes, Kenya Bureau of standards or equivalent ASTM Specification:

BS 8110, EN 1992-2	Reinforced concrete design

12105 MATERIALS

1. Cement and admixture (Silica fume)
2. Aggregates
3. Rebars
4. Water
5. Super plasticizer

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

12106 ORDER OF WORKS

1. Removal of Deteriorated Concrete

All loose or deteriorated concrete shall be removed as directed by the Engineer. Surface cracks shall be removed by chipping. Hammer sounding shall be done to locate delaminated areas. Care shall be taken not to damage areas of sound concrete, reinforcing steel or other bridge components. Any such damage shall be repaired at the Contractor's expense.

Removal of deteriorated concrete from the bridge structure shall be done in such a manner that the structural integrity of the bridge is unaffected. All concrete removed shall be replaced as soon as possible.

Surface treatment shall be carried out to ensure integration with the existing piers. The corners of the piers shall be chamfered as directed by the Engineer.

2. Additional Rebar

Additional rebar shall be firmly anchored into the drilled hole filled with epoxy resin adhesive and arranged in conformity with the requirements shown in the drawings. Prior to drilling holes, location of existing rebar in the pier shall be verified using an ultrasonic recorder (rebar locator). Actual ideal location of drilled holes for the additional rebars shall be consequently marked.

When reinforcing steel appears corroded during concrete removal, further chipping shall be done until clean and uncorroded portion of the bars are exposed. Chipping shall be done to a depth of 20 mm beneath the rebar. Perimeter of all chipped areas shall be saw cut to a minimum depth of 40 mm to minimize rough edges.

Rebar, which are exposed with 20% section loss during repairs, shall be replaced as directed by the Engineer. In cases of isolated section loss areas, the existing rebar shall not be cut out, instead, extra rebar shall be added alongside in such a manner that voids shall not occur during concrete placing.

The minimum lap length of all new rebar required shall be in accordance with the Engineer's instructions.

The minimum cover of new concrete above the reinforcing steel shall be in accordance with the drawings and Engineer's instructions. (May consider 40 mm in normal environment and 55 mm in the marine environment.)

3. Setting up of Formworks

The Contractor shall submit shop drawings, for the Engineer's approval, of the formwork for the concrete jacket prior to commencement of the repair works. The formwork must be very rigid and well-supported to prevent the new concrete from leaking at the bottom of the formwork. It should also be durable enough to withstand its own weight, pumping forces, (if concrete is to be pumped into the forms) and forces due to clamped-on external vibrators.

Circular formwork, when required, should be made up of steel plate or appropriate materials approved by the Engineer. The diameter of the formwork shall be fabricated 500 mm larger than the existing pier or pile diameter. This is necessary in order to provide a space of 250 mm between the formwork and the surface of existing concrete, which is required for placing new concrete and inserting poker vibrators.

4. Placing of Concrete

Concrete shall be placed in the formworks through a suitable method directed by the Engineer and compacted well using internal or external vibrators. Surfaces shall then be finished to match the adjacent existing concrete to Engineer's satisfaction.

Placing of concrete shall be in accordance with section 7400 of the Standard Specifications for Road and Bridge Construction.

5. Curing Concrete

Continuous water curing using wetted cotton mat is preferable to help slow down drying. Formworks for load bearing structural members shall remain in position until at least 80% of the 28 day compressive strength of the new concrete is achieved.

12107 MEASUREMENT AND PAYMENT

Item: Jacketing with concrete

Unit: Ton, m^3 and m^2

Measurements shall be in tonnes of steel, cubic meters of concrete and square meters of formwork used.

Payment shall include full compensation for provision of materials, labour, tools, equipment and other necessary accessories to complete the works.

12200: REPAINTING

12201 SCOPE OF SECTION

This section covers preparation of steel surface, filling voids, painting, checking of paint thickness and historical record marking. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

12202 GENERAL

Corrosion arrest shall be categorised under four categories;

1st Grade: Corrosion is very severe on steel surface and coating film is not visible due to corrosion. Affected surface area is over 30%.

2nd Grade: Corrosion is severe on steel surface and coating film is visible but almost deteriorated due to corrosion. Affected surface area is over 30%.

3rd Grade: Corrosion is partially severe on steel surface and coating film is almost visible but partially deteriorated due to corrosion. Affected surface area is 20 to 30%.

4th Grade: Corrosion is partially visible but not severe. Peel-off of Coating film is partially visible. Affected surface area is 10 to 20%.

Repainting shall be based on severity assessment as per the grades mentioned above.

12203 DEFINITIONS

Repainting refers to the application of a new coat of paint to an existing painted surface.

Repainting ensures the severity of rust is stopped.

12204 APPLICABLE STANDARDS

ASTM D520, BS 4652:1995	Epoxy Zinc Rich Primer (SSPC-Paint No.20) for 1st coat as primer
ASTM D520, BS 4652:1995	Epoxy Zinc Rich Primer (SSPC-Paint No.20) for 2nd Coat as Top Coat (For Lower Flange Plate)
ASTM D1652, BS 3900	Modified Epoxy Polyimide Paint (SSPC-PS13.01) for 1st coat as primer
ASTM D1652, BS 3900	Modified Epoxy Polyimide Paint (SSPC-PS13.01) for 2nd coat as top coat (for lower flange plate)
ASTM D16, BS EN 4588:2007, BS 3900	Polyurethane Paint (SSPC-Paint No.36) for 3rd Coat as Intermediate Coat
ASTM D16, BS EN 4588:2007, BS 3900	Polyurethane Paint (SSPC-Paint No.36 for 4th Coat as Top Coat

The material shall be approved by the Engineer through mill certificate of the supplier.

The repainting for 2nd grade surface preparation shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocodes or equivalent ASTM Specification:

Surface Preparation: Power Tool Cleaning to remove existing paint, rust, scale, stains and other foreign matters. Solvent cleaning by lacquer thinner to remove dirt, oil, grease and other contaminants. All surfaces to be painted shall be dry and free from dust (SSPC-SP10).

ASTM D16, BS 3900	Polyurethane Paint (SSPC-Paint No.36) for 3rd coat as intermediate coat
ASTM D16, BS 3900	Polyurethane Paint (SSPC-Paint No.36) for 4th coat as top coat

The material shall be approved by the Engineer through mill certificate of the supplier.

12205 MATERIALS

1. Epoxy zinc-rich primer
2. Modified epoxy polyimide paint
3. Polyurethane Paint – Thinner

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

12206 ORDER OF WORKS

1. Surface preparation

a) Preparation for paint removal

If hazardous substances affecting the human body are identified, they shall be removed in accordance with the relevant legislation.

b) Preliminary adjustment

In the case of dust adhesion or salt adhesion of 50 mg/m^2 or more, the surface shall be cleaned with fresh water immediately before painting in order to prevent delamination of the paint film.

c) Time of surface preparation

Surface preparation shall be carried out immediately before painting. The first layer must be finished within the specified time, as the surface to which the preparation has been carried out is susceptible to environmental influences, especially where steel surfaces have appeared, which react with oxygen and moisture in the atmosphere to produce rust in a short period of time. If the first layer cannot be finished due to sudden changes in the weather or other circumstances, the uncoated surfaces shall be reconditioned.

d) Checking the surface preparation and the surface finish of the edges of the component.

The surface to be painted shall be checked for a good degree of surface preparation and surface roughness, and that the required curved surface treatment of the edges of the component has been carried out properly.

The surface to be coated shall be thoroughly cleaned free of dust, sand, oil, grease and other harmful substances. If sea salt particles are thought to be adhering to the surface to be coated, the surface shall be thoroughly rinsed before painting.

Areas where painting is not to be carried out shall be masked to prevent paint from adhering to them.

2. Material preparation

a) Paint

Care and attention shall be paid in handling of the material to ensure that its consistency and viscosity is maintained in transport handling and storage. Expiry dates shall be checked to ensure that the manufacturer's stipulated dates are complied with.

b) Mix proportions

The paint to be used shall be adjusted to the appropriate viscosity according to the painting method, the amount of paint applied and the temperature at the time of painting. In this case, if a diluent (thinner) is unavoidably used, the amount of the diluent shall be kept to a minimum, weighed accurately and added, and the diluent shall be from the same manufacturer as the paint. However, diluents shall not be used for solvent-free paints.

In cases where diluents are separate materials care shall be maintained as the mix proportions are being done to be consistent with proportions, weight requirements and consistency requirements.

In cases where mechanical agitations are required, surface of the agitators and agitation temperatures shall be consistent with manufacturer's instructions.

c) Application timelines after mixing

Care shall be observed on manufacture's timeline recommendations for application after mixing diluents. Diluent properties as specified by manufacturer shall inform painting timelines post mixing.

3. Repainting

a) Paint application

i On-site painting shall be based on brush application and airless spray application.

ii When multi-component paint mixtures are used, paint that has exceeded its pot life shall not be used. Wet paint shall be used as appropriate during painting.

iii Wet film gauges shall be used to control film thickness as necessary during the coating process. The correlation between wet film thickness and dry film thickness for each paint to be used shall be obtained from the paint manufacturer in advance.

b) Conditions prohibiting painting work

Coating shall not be carried out in the following conditions:

i Temperature and humidity must be in accordance with the coating standards.

ii In the case of outdoor painting, when it rains, snows or strong winds occur or are likely to occur.

iii When the painted surface is wet due to condensation, etc. and is expected to remain so.

iv When the surface temperature of the painted surface is below the temperature specified in proper criterion or above 50°C.

v When foreign matter is expected to adhere to the surface during drying (curing) of the coating film.

vi When the surface preparation is not carried out as specified.

vii When the specified intervals between coats have not been taken.

viii When mud, oil, grease, dust, etc. adhere to the painted surface.

ix If the paint used has exceeded the specified usable time.

x If the paint is not sufficiently mixed, agitated or diluted.

xi In other cases where the Engineer considers it inappropriate.

c) Coating intervals

The interval between coats shall be within the limits specified for each coating system. The coating shall be applied after the lower coating has sufficiently dried (hardened). In corroded areas, the surface of the steel material is activated after blasting and rusting occurs at an early stage (turning phenomenon).

Coating conditions of the surface to be coated

i Before the first layer of primer coating, the surface shall be free from moisture, oil, grease, dust, rust, slag, abrasive, etc. as specified in the preparation.

ii For the second and subsequent layers of coating, it is to be ensured that the underlying coating is suitable for the layers to be painted. In addition, there shall be no adhesion of moisture, oil, grease, dust, rust, slag abrasive, etc. and no defects in the coating film.

d) Repainting

The painted surface shall be inspected after painting is completed and if there are any coating defects, the surface shall be repainted as soon as possible in accordance with the Engineer's instructions.

e) Work control

i Work control items

A. The work management personnel are to control and record the following items.

B. Degree of surface preparation, elapsed time after surface preparation (conditions).

C. Condition of paint used, amount of paint used, storage of paint.

D. Environmental conditions of the work, coating conditions of the coated surface, appearance of the coating, intervals between coats, thickness of the coating film.

E. Areas where surface preparation is not possible.

ii Confirmation of surface preparation

A. The surface shall be observed to check the degree of surface preparation as specified.

iii Condition of paints used

A. Paint to be used shall be within the date of manufacture and expiry date (generally within 1 year of manufacture).

B. After the paint cans have been opened, the condition of the paint shall be checked, including the state of the coating skin, colour separation, solidification (gel), separation and colouring.

C. For multi-component paint mixtures, the mixing ratio and whether the paint is used within the usable time after mixing.

D. Dilution of paints by diluent (thinner), the proportion and viscosity of the paint to be applied.

4. Curing

Paint layer shall be protected from debris and other contaminants after application in order to maintain smooth surface.

5. Historical record marking.

The painting historical record shall be marked on the bridge surface. This shall be marked on web plate, near the bearing.

12207 MEASUREMENT AND PAYMENT

Item: Repainting.

Unit: m^2

Measurement shall be in square metre.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for repainting as detailed in plans and specifications.

12300: STEEL PLATE ADDING

12301 SCOPE OF SECTION

This section covers surface preparation, surface treatment, drilling holes for High Tension Bolts (HTB), assembling of flat plate and angular plate, epoxy caulking, tightening of HTB, painting and historical record marking. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

12302 GENERAL

This method covers the repair and reinforcement in which steel plates are attached to existing steel members in accordance with the drawings and Engineer's instructions.

12303 DEFINITIONS

Steel plate adding refers to strengthening of the steel member to restore the original designed area.

High tension bolts are used for high-stress fastening applications.

12304 APPLICABLE STANDARDS

Related materials for this repair method shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent ASTM Specification:

ASTM A36, BS 5950-2	Flat/Angular plates
ASTM A325, BS 4395-1	High Tension Bolt

The epoxy putty shall be in accordance with the provisions of the relevant clauses of the following Eurocodes or equivalent ASTM Specification:

ASTM D792, BS EN 1504-4	Specific Gravity
ASTM D790M, BS EN 1504-4	Flexural Strength
ASTM D695M, BS EN 1504-4	Compressive Strength
ASTM D695M, BS EN 1504-4	Modulus of Elasticity
ASTM D638M, BS EN 1504-4	Tensile Strength
ASTM D1002, BS EN 1504-4	Tensile Shear Bond
ASTM D7234, BS EN 1504-4	Bond Strength to carbon fiber plate and Concrete

The material shall be approved by the Engineer through mill certificate of the supplier.

The Polyurethane Aluminium Painting for 1st grade surface preparation shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

Surface Preparation: Near white Blast Cleaning shall be done to remove paint, rust, scale, dirt, grease or other foreign matters. Solvent cleaning by lacquer thinner to remove dirt, oil, grease and other contaminants. All surfaces to be painted must be dry and free from dust (SSPC-SP10).

ASTM D520, BS 4652:1995	Epoxy Zinc Rich Primer (SSPC-Paint No.20) for 1st coat as primer
ASTM D520, BS 4652:1995	Epoxy Zinc Rich Primer (SSPC-Paint No.20) for 2nd Coat as Top Coat (For Lower Flange Plate)
ASTM D1652, BS 3900	Modified Epoxy Polyimide Paint (SSPC-PS13.01) for 1st coat as primer
ASTM D1652, BS 3900	Modified Epoxy Polyimide Paint (SSPC-PS13.01) for 2nd coat as top coat (for lower flange plate)
ASTM D16, BS EN 4588:2007, 3900	Polyurethane Paint (SSPC-Paint No.36) for 3rd Coat as Intermediate Coat
ASTM D16, BS EN 4588:2007, 3900	Polyurethane Paint (SSPC-Paint No.36） for 4th Coat as Top Coat

The material shall be approved by the Engineer through mill certificate of the supplier.

The Polyurethane Aluminium Painting for 2nd grade surface preparation shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent ASTM Specification:

Surface Preparation: Power Tool Cleaning to remove existing paint, rust, scale, stains and other foreign matters. Solvent cleaning by lacquer thinner to remove dirt, oil, grease and other contaminants. All surfaces to be painted must be dry and free from dust (SSPC-SP10).

ASTM D16, BS 3900	Polyurethane Paint (SSPC-Paint No.36) for 3rd coat as intermediate coat
ASTM D16, BS 3900	Polyurethane Paint (SSPC-Paint No.36) for 4th coat as top coat

The material shall be approved by the Engineer through mill certificate of the supplier.

The special anti-corrosion paint shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent ASTM Specification:

The total quantity of Anti-Corrosion Paint shall exceed 1.5kg/m^2 for two coating application.

1st layer Anti-Corrosion Paint: 250μm

2nd layer Anti-Corrosion Paint: 250μm

ASTM D7234, BS 3900	Adhesive test
ASTM C190, BS 3900	Elongation
ASTM D6943, BS 3900	Saltwater test

The materials shall be selected in accordance with manufacturer's instructions.

12305 MATERIALS

1. Flat plate and angular plate
2. High Tension Bolts (HTB)
3. Epoxy putty

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

12306 ORDER OF WORKS

1. Surface preparation

All surfaces to be provided with additional steel plates shall be thoroughly cleaned of all rust, dirt, oil or grease, and other foreign substances. The surfaces to be painted shall then be lightly grinded to increase adhesion of the new paint required.

The grade of surface preparation shall conform to section on repainting system or shall be as recommended by the manufacturer.

2. Surface treatment

After surface preparation, epoxy putty shall be applied to level the surface of the existing steel plate and recover its original thickness and shape.

3. Drilling holes for HTB

Templates for bolt holes for the additional flat plate or angular plate, which shall be fabricated at the factory, shall be prepared based on the actual positioning required at site.

Holes for the HTB shall be drilled through the plates using portable electric drill or electric coring drill. Suggested diameter of hole shall be between 25 mm to 27 mm, intended for M22 HTB.

4. Assembling of flat plates and angular plates.

Additional flat plates and angular plates shall be placed on the actual bottom flange locations for purposes of installing HTB.

After installation, each HTB shall be first fastened with electric fastener.

5. Epoxy caulking

Small gaps found between the new plate and existing steel plate shall be filled with epoxy caulking.

6. Tightening HTB

This shall be in accordance with section 12500 of this specification.

7. Painting

After installation of the steel plates and HTB are completed, polyurethane aluminium paint shall be applied in accordance to section 12200 of this specification.

Portions of steel plate where section loss or severe corrosion is found shall be painted with anti-corrosion paint as protection against further rusting in accordance to section 12600 of this specification.

8. Historical record marking

Historical record for the repair measure performed shall be marked on the web plate near the bearing.

12307 MEASUREMENT AND PAYMENT

Item: Steel plate adding

Unit: Ton, No.

Measurement shall be in tonnes for the steel plates and number for the bolts**.**

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for strengthening the steel plate adding as detailed in plans and specifications.

12400: CARBON FIBRE BONDING

12401 SCOPE OF SECTION

This section covers furnishing and installation of carbon fibre plates and adhesive resin such as epoxies to enhance the capacity of steel bridge members. All repair work shall be carried out in accordance with the drawings, specifications, manufacturer's guidelines and Engineer's instructions.

12402 GENERAL

This method is used to reinforce the lower flanges and/or web against reduction of load-bearing capacity of steel bridge components. Carbon Fibre Plate (CFP) shall be installed at the portion of existing steel members where section loss is more than 20% in order to restore the lost strength. This repair method shall be further supplemented by repainting or by application of anti-corrosion coating.

12403 DEFINITIONS

This involves application of carbon fibre plates to steel bridge surface using epoxy resin adhesive.

12404 APPLICABLE STANDARDS

The carbon fibre plate shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocodes or equivalent ASTM Specification:

BS 7658-1	Carbon fiber plate weight
BS 7658-1	Carbon fiber plate density
ASTM D3039, BS ISO 14127:2006	Tensile Strength
ASTM D7234, BS EN 1504-4	Bond Strength to Steel

The epoxy adhesive for bonding carbon fibre plate shall be in accordance with the provisions of the relevant clauses of the following British Standard:

ASTM D792, BS EN 1504-4	Specific Gravity
ASTM D790, BS EN 1504-4	Flexural Strength
ASTM D695, BS EN 1504-4	Compressive Strength
ASTM D695, BS EN 1504-4	Modulus of Elasticity
ASTM D638, BS EN 1504-4	Tensile Strength
ASTM D1002, BS EN 1504-4	Tensile Shear Bond
ASTM D7234, BS EN 1504-4	Bond Strength to Carbon Fiber Plate and Steel

12405 MATERIALS

1. Carbon fibre plates

The tensile strength and tensile modulus of elasticity of carbon fibre plates, impregnated and cured with impregnation and adhesive resin, shall be measured according to relevant standards. The tensile strength shall be the guaranteed strength obtained from material tests (mean value of breaking strength - 3 x standard deviation) and the tensile modulus shall be the mean value of material tests.

2. Primer

The primer shall be a two-component (two-component mixture) epoxy resin, which shall ensure sufficient adhesion between the steel surface and the carbon fibre plate.

3. Impregnation and adhesion resins

The resin must be able to impregnate carbon fibres reliably and ensure Young's modulus, tensile strength, bonding strength and joint strength of the carbon fibres, and must have a viscosity suitable for the work.

4. Surface adjustment materials

Epoxy resin-based putty shall be standard and shall be capable of sufficient adhesion to primers and impregnation/adhesion resins, and shall have properties suitable for the work.

5. Finishing materials

Where protection by surface finish materials alone is deemed inappropriate, e.g. when considering collisions with travelling vehicles or when used to reinforce in-river piers, special protective works shall be considered separately.

12406 ORDER OF WORKS

1. Preparation of steel surface

The disc grinder or abrasive sandblasting shall be used to clean the steel surface and to ensure that the surface is even and smooth. The bonding positions of the carbon fibre sheet shall be marked on the steel surface to ensure the straightness of the carbon fibre sheet.

2. Application of epoxy primer

Primer shall be applied to the prepared existing steel surface to improve adhesion to the carbon fibre sheet.

Ensure that the steel surface is sufficiently dry when applying the primer so that its function is not impaired. As a general rule, construction must not be carried out when the temperature is below 5°C or when the humidity is above 85%.

However, this does not apply if appropriate measures are taken, such as keeping the construction site warm or using a primer specifically designed for wet surfaces.

3. Adjustment of unevenness

Surfaces of corroded steel plate may have holes and dents. Epoxy putty shall be applied to level the surface of the existing steel plate and recover its original thickness and shape. The surface where the epoxy putty has been applied shall be smoothened using 60 - 100 sandpaper.

4. Application of epoxy resin for undercoat

Using a roller, epoxy resin shall be applied to the steel as an adhesive to bond with the CFP. It shall form a moulded composite by permeating into the CFP.

5. Installation of Carbon Fibre Plate (CFP)

An epoxy-based adhesive shall be applied to the CFP using an applicator to bond. To reduce formation of voids, the adhesive shall be spread to form a curved profile that measures 3 mm at the centre and 1 mm at the edges. CFP shall be installed manually by applying uniform pressure along the longitudinal centreline.

6. Squeezing out entrapped air

For complete fusion, the entrapped air shall be squeezed out of the carbon plates using a roller, before the applied adhesive sets.

7. Clamping of CFP

The bonded CFP shall then be clamped to the member being strengthened for at least 24 hours to allow the initial resin saturate to dry.

12407 MEASUREMENT AND PAYMENT

Item: Carbon fibre plate bonding

Unit: m^2

The method of measurement for this repair method shall be by square meter of carbon fibre plate, checked and approved by the Engineer. Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for the works as detailed in plans and specifications.

12500: TIGHTENING/RETIGHTENING OF HIGH-TENSION BOLTS

12501 SCOPE OF SECTION

This section covers replacement of missing and removal of severely corroded high-tension bolts, surface preparation, fixing and fastening of new high-tension bolts, quality control of high-tension bolt fastening and painting.

All repair work shall be performed strictly in accordance with the specifications and Engineer's instructions.

12502 GENERAL

Deterioration of high-tension bolts used in in-situ joints of steel bridge elements affects the load-bearing capacity of the joints and may cause the high-strength bolts to fall off the girders.

12503 DEFINITIONS

This refers to replacing or retightening of missing or loosened High-Tension Bolt (HTB) connection for steel elements in the field during maintenance inspection.

12504 APPLICABLE STANDARDS

The High-Tension Bolt (HTB) shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocodes or equivalent ASTM Specification:

ASTM A325 (AASHTO M164), BS 4395-1	High Strength Heavy Hex Structural Bolts
BS EN 14831: 2005	Tightening standards

12505 MATERIALS

1. High Tension Bolts
2. Grease
3. Anti-rust spray
4. Yellow paint

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

12506 ORDER OF WORKS

1. Removal of High-Tension Bolt (HTB)

If the HTB is found to be severely corroded, it shall be removed from the plate using an electric drill, hammer, wrench, and spanner with long handle. Where removal using the said devices remains difficult, the bolt shall be cut using acetylene gas.

2. Surface preparation

After rinsing with water, all adhering rust, scale, dirt, grease or other foreign material shall be removed from the steel plate.

3. Fastening HTB

a) Primary tightening shall be carried out on all bolts by rotating the bolt at the appropriate torque value.

b) After primary tightening, the bolts, washers and plates shall be marked to confirm primary tightening, measure the amount of bolt rotation, prevent over-tightening and detect co-rotation.

c) Main tightening shall be carried out by rotating the bolt 120° starting from the marking after primary tightening.

4. Quality control of HTB fastening

HTB shall finally be fastened using Rotation Angle Method as a means of quality control to meet the required design tensile stress. The fastening rotation angle shall be 120°±30° from the location of the yellow marking.

6. Finishing surface preparation

After fastening all the HTB, grease or other oil material shall be removed using solvent material. New HTB shall be covered with grease to control rotation friction.

7. Painting

Repainting of the finally fastened HTB shall be in accordance with section 12200 of this specification.

8. Inspection after tightening

a) As a rule, all bolts shall be inspected in the presence of a supervisor to ensure that the required rotation angle has been obtained based on the markings after primary tightening.

b) The bolt rotation angle shall be acceptable within ± 15° of the specified rotation angles.

c) High-tension bolts with an excessive amount of rotation shall be replaced.

d) High-tension bolts with insufficient turnover shall be retightened to the required turnover.

e) Once used, high-tension bolts shall not be re-used.

12507 MEASUREMENT AND PAYMENT

Item: Tightening / retightening of high-tension bolt

Unit: Ton and No.

Measurements shall be in tonnes for new bolts and number for retightening.

Payments shall include full compensation for supplying all labour, materials, tools, equipment, and incidental items. This also includes furnishing, preparing, fabricating, transporting, placing, fastening and greasing of the HTBs.

12600: ANTI-CORROSION PAINT

12601 SCOPE OF SECTION

This section covers all preparation of steel surfaces, mixing anti-corrosion paint and painting. All paint repair work shall be performed in accordance with the Engineer's instruction, standard specification and this specification.

Anti-corrosion paint shall be applied to the portion of steel plate that has section loss of more than 10% but less than 20%. This repair method is also applied in combination with repainting repair method under section 12200 of this specification.

Anti-corrosion paint is applied to maintain good surface condition of bridges situated in severely active environment, subjected to wind-borne sea water spray.

12602 GENERAL

Anti-corrosion paint is applied to deter propagation of deterioration of steel members.

12603 DEFINITIONS

Anti-corrosion paint is ideally applied to protect steel materials.

Environmental exposure has a great impact on the effectiveness and suitability of an anti-corrosion paint.

12604 APPLICABLE STANDARDS

The anti-corrosion paint shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

ASTM D7234, BS 3900	Adhesive test
ASTM C190, BS 3900	Elongation
ASTM D6943, BS 3900	Saltwater test

The material shall be selected in accordance with manufacturer's instructions.

The total quantity of Anti-Corrosion Paint shall exceed 1.5kg/m^2 for two coating application.

1st layer Anti-Corrosion Paint: 250µm

2nd layer Anti-Corrosion Paint: 250µm

12605 MATERIALS

The contractor shall comply with the provisions of section 1722 on Paints for Structures in MATERIALS AND TESTING OF MATERIALS and section7900 PAINTING in STRUCTURAL STEELWORK" of Standard Specifications for Road and Bridge Construction.

1. Emulsion
2. Compound

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

12606 ORDER OF WORKS

1. Preparation of steel surface

After rinsing with water, all adhering rust, scale, dirt, grease or other foreign material shall be removed to clean the identified surfaces.

The 3rd Grade surface preparation is commonly adopted for the steel surface, using wire brush and electric disc grinder.

Undamaged coating film may be maintained. It shall not be necessary to completely remove rust using the disc grinder, as this will be arrested after application of the anti-corrosion paint.

2. Mixing paint

The compound and emulsion shall be properly mixed to attain the expected quality of the Anti-corrosion paint. A mixing ratio of 1:2.3 shall be required between emulsion and compound.

No water shall be added to the mixture during the mixing process. If the mixed powder becomes dry while being stored, emulsion shall be added to maintain consistency. The mixing of the paint materials shall be followed as per the manufacturer's instructions.

3. Painting

To avoid negative impacts to environment at the site as well as appreciate savings on materials, the paint shall be applied using either paint brush or roller.

Hand painting with brushes shall be carefully executed and controlled to maintain the required quality of coating film thickness.

To ensure consistency, the coating film thickness shall be measured under dry condition, using a thickness gauge.

If the applied paint is damaged by electric grinder while removing some dust particles, over coating of the anti-corrosion paint shall be provided.

4. Curing

The coating film should completely dry within a day, under a temperature of 30˚C. During rainy season, drying time should be more than 2 days. Nevertheless, once the coating dries, water is not expected to affect the surface.

5. Inspection

The paint film thickness shall be measured using thickness gauge to verify consistency of thickness. The minimum thickness allowed shall be 70% of the required value, similar to the quality control adopted for ordinary painting system.

6. Historical Record making

It is important to mark on the bridge surface, the Painting Historical Record. This shall be marked on web plate, near the bearing.

12607 MEASUREMENT AND PAYMENT

Item: Anti-Corrosion Paint

Unit: m^2

Measurement shall be by square meters.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for painting the structure as detailed in plans and specifications.

12700: ASPHALTIC PLUG JOINT

12701 SCOPE OF SECTION

This section covers dismantling of existing damaged asphalt joint sealant, chipping surface concrete, installation of steel frame, rebar anchor, pouring flexible asphalt, installation of expansion sheet and pouring flexible asphalt. All repair work shall be carried out in accordance with the specifications and Engineer's instructions.

Works under this section include removal and replacement of damaged asphaltic plug joint. Asphalt plug Joints have average width of 50mm.

12702 GENERAL

The quality of expansion joints is vital to the behaviour of the bridge and its durability.

Expansion joint needs to be maintained by waterproofing and ensuring resistance to leakage. The most common joint sealant is asphalt which is easily damaged with repeated traffic load and aging.

12703 DEFINITIONS

Asphaltic plug joint is a simple bridge expansion joint filled with asphalt. Asphaltic plug joint is made of special type elastic material (elastic-plastic material) with high viscosity.

12704 APPLICABLE STANDARDS

The pre-fabricated steel frame shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent ASTM Specification:

ASTM A36, BS 5950-2	Pre-fabricated steel frame

The flexible asphalt shall be in accordance with the provisions of the relevant clauses of the following Eurocodes or equivalent ASTM Specification:

ASTM D1188, BS EN 13108-1	Density
ASTM D4123-82, BS EN 13108-1	Splitting Strength
ASTM D1559, BS EN 13108-1	Deformation (Flow value)

The material shall be approved by the Engineer through mill certificate of the supplier.

12705 MATERIALS

1. Steel frame (welded with anchor rebar)
2. Concrete anchor with steel bar
3. Expansion sheet
4. Flexible Asphalt or asphalt-rubber chip

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

12706 ORDER OF WORKS

1. Preparation

The joint gap of the joint device shall be checked in advance to ensure that it is appropriate for the installation temperature.

The installation height shall be surveyed and confirmed in advance. The installation section of the joint device shall be measured in advance to confirm the time when there is the least change in the amount of expansion and contraction.

2. Installation

a) Dismantle existing damaged asphalt joint sealant

The damaged joint sealant shall be dismantled and removed for appropriate disposal.

b) Chipping surface concrete

The surface of concrete at the location of the existing damaged joint shall be chipped off for purposes of installing new steel frame and to insert the foam to narrow gap (proper gap for seamless joint is less than 25mm).

c) Installation of steel frame

Steel frame shall be fabricated in a box frame and rebar. This frame shall be fixed by welding between Concrete anchor and rebar.

d) Rebar anchor

Besides intersection of rebar, the concrete anchor shall be inserted for every intersection of rebar.

e) Pouring flexible asphalt 1st layer

Flexible Asphalt shall be poured to the chipped off edges. The height of pouring is half of total thickness to be installed.

f) Installation of expansion sheet

Expansion Sheet shall be spread on the first layer of flexible asphalt.

g) Pouring flexible asphalt 2nd layer

Flexible asphalt (asphalt-rubber chips) shall be poured as second layer.

The surface of flexible asphalt shall not be compacted until the temperature falls to room temperature.

3. Finishing

a) Installation shall be carefully carried out so as not to cause unevenness, twisting, or other distortions.

b) The floor slab reinforcement at the joint device installation area must be accurate and well connected to the anchors of the joint device.

c) Joint devices and bridge girders (slabs) shall be installed sufficiently and evenly with set bolts or no-shrink mortar. When liner plates are used for height adjustment, care must be taken to avoid localized bearing pressure conditions.

d) If the water stop material has joints, the connection method specified by the manufacturer in the installation manual must be followed.

4. Opening of traffic to construction vehicles

If the bridge face is to be opened to traffic for construction road purposes prior to the completion of the bridge face pavement, necessary measures such as temporary pavement in the vehicular traffic lanes and speed and weight limit enforcement shall be taken to prevent adverse effects not only on the floor slabs but also on the joint devices. The details of these measures shall be confirmed by the engineer.

12707 MEASUREMENT AND PAYMENT

Item: Asphaltic Plug Joint

Unit: m

Measurement shall be in linear meters.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for the repair of asphaltic plug joint as detailed in plans and specifications.

12800: REPLACEMENT OF EXPANSION JOINT

12801 SCOPE OF SECTION

This section covers cutting of concrete surface, chipping off concrete / dismantling expansion joint, setting up new expansion joint and pouring concrete. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

12802 GENERAL

This specification covers the standards of the material, order of works and application requirements for replacement of expansion joint for bridges.

12803 DEFINITIONS

The behaviour of the bridges and their durability depends on the quality and maintenance of the expansion joints. It should be ensured that the expansion joints are waterproofed as well as resistant to leakage.

When water leakage occurs at expansion joints, dirt, soil, gravel and water are collected on the bearing seat locations. This condition initiate corrosion of steel members including the steel bearings, bottom flanges at ends of steel girder and steel connection accessories.

12804 APPLICABLE STANDARDS

The new expansion joint shall be in accordance with the provisions of the relevant clauses of the following British Standard, or equivalent ASTM Specification:

ASTM A36, BS 5950-2	Steel plates and anchor bars

The polymer cement mortar shall be in accordance with the provisions of the relevant clauses of the following British Standard, or equivalent ASTM Specification:

ASTM C39, BS 6319-2	Compressive Strength
ASTM D7234, BS 6319-4	Bonding Strength to Concrete
ASTM C39, BS 6319	Bleeding Rate

The material shall be approved by the Engineer through mill certificate of the supplier.

The expansion joint rubber seal shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent ASTM Specification:

ASTM D412, BS 903	Tensile Strength
ASTM D412, BS 903	Elongation at break

The type and size of rubber seal for expansion joint should be determined based on manufacturer's instructions. The material test shall be applied for tensile strength and elongation to be approved by the Engineer.

12805 MATERIALS

1. Expansion joint with water proof rubber
2. Rebar (16 mm diameter)
3. Concrete/grout
4. Concrete bonding agent

The materials shall be in accordance with the provision in the specifications and approved by the Engineer

12806 ORDER OF WORKS

1. Cut the concrete surface

Concrete surrounding the damaged expansion joint shall be hacked using an electric saw and cart away waste concrete.

2. Chipping off concrete/dismantling the expansion joint

Concrete shall be continuously chipped off to achieve the required positioning for the new expansion joint. Exposed existing rebars shall remain to maintain the strength.

The damaged expansion joint shall then be dismantled and removed after chipping off the concrete.

3. Installation of new expansion joint

The new expansion joint with water-proof device shall be installed. Transverse rebar (16 mm diameter) shall be fixed with mechanical anchors.

Installation shall be carried out during ambient temperatures to prevent expansion and contraction.

Care shall be taken to prevent twisting, unevenness or other distortions of the expansion joint.

After the installation is completed, the condition of the installation, such as installation height and tightness of set bolts, and the condition of cleaning shall be inspected before concrete is poured. The installation shall comply with the manufacturer's specifications.

4. Pouring concrete

After verification measurements, concrete shall be poured, and then cured, to complete the works.

Prior to the placement of concrete in the anchorage area, the joints between the old and new concrete shall be adequately treated to prevent structural weaknesses.

Concrete shall be placed so that it completely covers the joint device anchorages.

The concrete to be placed shall be of equal or better quality than the main concrete.

5. Curing

After the concrete is cast, it shall be cured by covering it with sheets and sprinkling water on it.

Concrete shall not be loaded until it has reached its design strength.

6. Completion inspection

Joint device sections shall be inspected for completion after concrete is placed.

12807 MEASUREMENT AND PAYMENT

Item: Replacement of expansion joint

Unit: m

Measurement shall be in linear meters.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for replacement of the expansion joint as detailed in plans and specifications.

12900: REPLACEMENT OF BEARING

12901 SCOPE OF SECTION

This section covers jacking up girder, dismantling the existing bearing and chipping bearing base, casting new bearing seat and setting up new bearing, jacking down girder after curing, dismantling jacks and temporary support for the final work. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

12902 GENERAL

This specification covers standards of the material, order of works and application requirements for replacement of bearing for bridges.

The purpose of a bearing is to allow controlled movement and thereby reduce the stresses involved. Possible causes of movement are thermal expansion and contraction, creep, shrinkage, or fatigue due to the properties of the material used for the bearing.

Effective service life of elastomeric bearings is estimated to be 15 – 25 years. As the material ages during its serviceability period, it exhibits severe bulging or cracking. These are signs that the elastomeric bearings need to be replaced.

Replacement with new bridge bearings shall be performed in accordance with the relevant technical requirements and recommendations provided by the bearing manufacturers.

12903 DEFINITIONS

A bridge bearing is a component of a bridge which typically provides a resting surface between bridge piers and the bridge deck.

12904 APPLICABLE STANDARDS

The elastomeric bearing pads shall be in accordance with the provisions of the relevant clauses of the following British Standard, or equivalent ASTM Specification:

AASHTO M251, BS 5400-9	Elastomeric bearing pads
ASTM D2240, BS 5400-9	Hardness, Durometer

The material test shall be applied for Hardness test to be approved by the Engineer.

12905 MATERIALS

1. Elastomeric bearing pads conforming to Eurocode EN1337-3 (Product standard)
2. Rebar conforming to Eurocode 3 (EN1993-1-1)
3. Mortar/concrete conforming to Eurocode 2 (EN 1992)

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

12906 ORDER OF WORKS

1. *Jacking up*

   Jacking up of the girder shall be carried out in accordance with specifications in section 13100 of this specification.

   If the bridge is to be supported by temporary bearings during the replacement of bearings, the safety of the temporary bearings during construction shall be checked for stability, as they are important components that support the weight of the bridge and the loads of passing vehicles.

2. *Dismantle existing bearing and chipping bearing base*

   The concrete bearing base shall be hacked off to remove the existing bearings.

3. *Cast new bearing seat and set up new bearings*

   After concrete removal, the new bed support replacement shall be installed using non-shrink grout. The new bearings shall be set up at appropriate position and level. The level shall consider additional factor such as compressive displacement of elastic rubber bearing.

4. *Jack down girder after curing*

   After curing of bearing seat, it shall be inspected to check the level and stability before the girder is jacked down and consequently supported by the new rubber bearing. Final position and height of the new bearing shall be verified, subject to approval of the Engineer.

   Jacking down shall be carried out after checking that the mortar has hardened.

   Jack down simultaneously on one bearing line and remove the hydraulic jack after confirming that the reaction force has been transferred to the new bearing. At that time, check that there are no deformations on the bearings, the shoe seat mortar or the girders.

5. *Dismantle jacks and temporary support for the final work*

   After replacement of the new rubber bearings is accomplished, jack device and temporary supports shall be dismantled. Steel surfaces shall be painted, if found necessary.

   Settlement shall be monitored in the days following the replacement.

6. *Corrosion protection*

   When replacing bearings, the anti-corrosion specifications and construction shall be in accordance with the relevant sections of this specification.

12907 MEASUREMENT AND PAYMENT

Item: Replacement of bearing

Unit: No.

Measurement

Payment shall be in number of bearings replaced.

The Payment shall cover full compensation for furnishing, preparing, fabricating, transporting, placing and installation.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for replacement of the expansion joint as detailed in plans and specifications.

13000: EXTENSION OF BEARING SEAT

13001 SCOPE OF SECTION

This section covers the extension of damaged bearing seat chipping and drilling holes, fitting of anchor bar, arrangement of rebars, formwork, and pouring concrete. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

13002 GENERAL

This specification covers the standards the material, order of works and application requirements for extension of damaged bearing seat for bridges.

13003 DEFINITIONS

Extension of bearing seat occurs when anchor bars are connected to the existing bearing seat to extend the seat width.

13004 APPLICABLE STANDARDS

The Portland cement mortar shall be in accordance with the provisions of the relevant clauses of Standard Specifications for Road and Bridge Construction.:

The strength test for Portland cement mortar shall be based on ASTM C780 or KS EAS 18-01.

The polymer cement mortar shall be in accordance with the provisions of the relevant clauses of the following British Standard, Kenya Bureau of standards or equivalent ASTM Specification:

ASTM C39, BS 6319-2	Compressive Strength
ASTM D 7234, BS 6319-2	Bonding Strength to Concrete
ASTM C39, BS 6319-2	Bleeding Rate

The epoxy adhesive to concrete shall be in accordance with the provisions of the relevant clauses of the following Eurocodes or equivalent ASTM Specification:

ASTM D695M, BS EN 1504-4	Compressive Strength
ASTM D790M, BS EN 1504-4	Flexural Strength
ASTM D638M, BS EN 1504-4	Tensile Strength
ASTM D1002, BS EN 1504-4	Tensile Shear Bond to Steel
ASTM C882, BS EN 1504-4	Slant Shear Bond to Mortar

The material shall be approved by the Engineer through mill certificate of the supplier.

Anchor bar shall be in accordance with the provisions of the relevant clauses of Standard Specifications for Road and Bridge Construction.

Portland Cement Mortar shall be in accordance with the provisions of the relevant clauses of Standard Specifications for Road and Bridge Construction. The strength test for Portland cement mortar shall be based on ASTM C780 or KS EAS 18-01.

The Polymer Cement Mortar (PCM) shall be in accordance with the provisions of the relevant clauses of the following British Standard or equivalent ASTM Specification:

ASTM C39, BS 6319-2	Compressive Strength
ASTM D7234, BS 6329-4	Bonding Strength to Concrete
ASTM C39, BS 6319	Bleeding Rate

The material shall be approved by the Engineer through mill certificate of the supplier.

13005 MATERIALS

1. Primer to Concrete Surface (Epoxy adhesive)
2. Concrete
3. Epoxy anchor bolts or anchor bars
4. Formwork

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

13006 ORDER OF WORKS

1. Chipping and drilling holes.

The spalled or delaminated portion shall be removed completely by hammer chipping or electric drilling. Holes for anchor bar shall be drilled using electric drill device.

Drilling of holes shall be performed carefully in order to avoid damaging the existing coping reinforcements.

2. Anchor bar fittings.

Drilled hole shall be filled with epoxy adhesive before completely placing required anchor bars.

3. Arrangement of bars

After anchor bars are bonded with the drilled holes, new rebar, connected to the anchor bars, shall be arranged for the proposed extension of bearing seat in accordance with the drawings.

4. Fixing of formwork

Formwork and required temporary supports shall be fixed immediately after application of bonding coats to concrete substrate and reinforcements.

5. Pouring of concrete

Concrete shall then be poured to the formed section. The rendered surface should match that of the existing structure.

6. Dismantling of formwork

The formworks shall be finally dismantled as directed by the Engineer.

7. Curing

After concrete is completely in place, finishing and curing shall be performed.

13007 MEASUREMENT AND PAYMENT

Item: Extension of bearing seat

Unit: m^3, Ton

Measurement shall be based on cubic metres (m) for concrete and tonnes (Ton) for steel.

The accepted quantities, measured as prescribed above shall be paid for at a contract unit price for each of the approved pay item included in the bill of quantities.

13100: JACK UP GIRDER

13101 SCOPE OF SECTION

This section covers the jacking up of two different types of girders into the following parts:

1) Concrete girder

This section covers preparation of materials, equipment and site cleaning, installation of jack base frame, jacking up, jacking down, verification of measurement, dismantling jacks and temporary supports. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

2) Steel girder

This section covers all preparation of materials, equipment and site cleaning, welding temporary jack stiffness, jacking up, jacking down, inspection of measurement, dismantling jacks and temporary supports. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

13102 GENERAL

This involves jacking up girder, removal of existing bearing and installation of new bearings (if the purpose is to replace bearings).

Jack up girder method is also applied for the cleaning of bearings, painting of bearings, repairing of bearings, replacement of bearings and re-arrangement of existing bearings.

The following should be observed:

1. The amount of jacking up shall be the amount necessary to cut the reaction force of the bearing, and 0 to 3 mm is standard.
2. When jacking up the girder, the entire bearing line should be raised uniformly, and only one bearing should not be jacked up.
3. Pressure insertion shall be performed slowly and while checking the pressure (reaction force) and height.
4. The pump for jacking should be a manual pump.

The jacks should be equipped with pressure-checking devices as necessary. The structure shall be capable of controlling hydraulic pressure and durable enough to withstand repeated loads caused by traffic.

13103 DEFINITIONS

This involves raising and lowering in place girder by use of hydraulic lift plant.

Jack up girder method is applied for cleaning of bearings, painting of bearing, repairing of bearing, replacement of bearings and re-arrangement of existing bearing.

13104 APPLICABLE STANDARDS

BS EN 13155

13005 MATERIALS

This is a day work operation.

13106 ORDER OF WORKS

1. Installation of jack base frame

For concrete structures, the jack-base bracket shall be installed using epoxy anchor through drilled holes for anchor bolts. Hydraulic jack with capacity furnished by designated structural engineer shall be set up on the jack-base bracket. Temporary supporting member shall also be provided.

For steel structures, jack stiffeners shall be welded to both sides of web plate. Jack-base bracket is installed using epoxy anchor installed at drilled holes for anchor bolts.

2. Jacking up

Jack-up operations shall be simultaneously carried out for all the girders. For this condition, jacking up height is limited to 3 mm for each jack-up motion.

The method shall be repeated gradually until the instructed jacking up height is achieved to allow for dismantling of the existing bearings. When jacking up, the entire bearing line shall be raised uniformly, and only one bearing shall not be jacked up.

Pressure insertion shall be carried out slowly and while checking the pressure (reaction force) and height.

Pumps for jacking shall be manual pumps.

The jacks shall be equipped with a pressure checking device as appropriate. The structure shall be capable of managing hydraulic pressure and durable enough to withstand repeated loads due to traffic.

3. Jacking down

Jack down shall commence once the works are completed and the mortar is hardened. Safety shall be maintained during this operation. Jacking down shall be carried out gradually while carefully removing the temporary supporting members.

Jack down simultaneously on one bearing line and remove the hydraulic jack after confirming that the reaction force has been transferred to the new bearing. At that time, confirm that there are no deformations in the bearings, the shoe seat mortar or the girders.

If the temporary support touches the lower surface of the girder during jack down operations, the jack base plate shall be changed with a lesser thickness. Stroke shall be extended to jack down. These steps shall be repeated in cycle. For safety purposes, each stroke shall maintain a height of less than 3 mm. See 2 above.

If the temporary support keeps touching the concrete surface, the jack shall be dismantled and the jack base plate removed gradually.

The temporary support shall be taken off from the concrete surface by jacking up slightly. The temporary support shall be dismantled gradually for every 3 mm jack down movement.

Once the concrete girder rests completely on the bearings during jacking down motion, the exact location between the girder and bearing shall be measured immediately. If dimensions are acceptable, the jack can be dismantled completely.

The displacement (settlement) shall be checked over time after jacking down for several days.

4. Verification of measurement

Verification measurement shall be conducted to ensure final height, and exact location of all bearing positions. If not satisfactory, re-jack operations shall be repeated to perform adjustments.

5. Dismantle jacks and temporary support

Jacks and temporary support materials shall be dismantled.

6. Completion

Clean-up site and ensure the measurements are approved by the Engineer.

13107 MEASUREMENT AND PAYMENT

Item: Jack up girder (Steel /concrete girder)

Unit: LS

Measurement shall be in lump sum for the length of the span jacked.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for jacking up the girder as detailed in plans and specifications.

13200: REPAINTING STEEL BEARING

13201 SCOPE OF SECTION

This section covers repainting and associated preparatory works for steel bearings. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

13202 GENERAL

This specification covers preparatory works, material preparation and repainting standards for steel bearings.

13203 DEFINITIONS

Steel bearings are provided at bridge abutments and piers. Typically, due to the deterioration of water proofing components at expansion joints over the years, steel bearings underneath the superstructure are subjected to corrosion.

13204 APPLICABLE STANDARDS

The repainting for various grades of corrosion as specified in section 12200 of this specification.

All other works shall comply with the provisions of the relevant clauses of the following British Standard, Eurocode or equivalent ASTM Specification:

ASTM D520, BS 4652:1995	Epoxy Zinc Rich Primer (SSPC-Paint No.20) for 1st coat as primer
ASTM D520, BS 4652:1995	Epoxy Zinc Rich Primer (SSPC-Paint No.20) for 2nd Coat as Top Coat (For Lower Flange Plate)
ASTM D1652, BS 3900	Modified Epoxy Polyimide Paint (SSPC-PS13.01) for 1st coat as primer
ASTM D1652, BS 3900	Modified Epoxy Polyimide Paint (SSPC-PS13.01) for 2nd coat as top coat (for lower flange plate)
ASTM D16, BS EN 4588:2007	Polyurethane Paint (SSPC-Paint No.36) for 3rd Coat as Intermediate Coat
ASTM D16, BS EN 4588:2007	Polyurethane Paint (SSPC-Paint No.36) for 4th Coat as Top Coat

The material shall be approved by the Engineer through mill certificate of the supplier.

The repainting for 2nd grade surface preparation shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocode or equivalent ASTM Specification:

The material shall be approved by the Engineer through mill certificate of the supplier.

The repainting for 3rd grade surface preparation shall be in accordance with the provisions of the relevant clauses of the following British Standard, or equivalent ASTM Specification:

ASTM D7234, BS 3900	Anti-Corrosion Paint for 1st coat
ASTM D7234, BS 3900	Anti-Corrosion Paint for 2nd coat as top coat

The material(s) shall be in accordance with the provision in the specifications and approved by the Engineer.

13205 MATERIALS

1. Zinc-rich base primer.
2. Polyurethane Aluminium Paint - Aluminium paint shall consist of aluminium bronze powder or paste of the required fineness and composition to which shall be added the specified amount of agent component.
3. Thinner.
4. Modified epoxy polyimide primer.
5. Anti-Corrosion paint.

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

13206 ORDER OF WORKS

1. Surface preparation

a) Preparation for paint removal

If hazardous substances affecting the human body are identified, they shall be removed in accordance with the relevant legislations.

b) Preliminary adjustment

In the case of dust adhesion or salt adhesion of 50 mg/m^2 or more, the surface shall be thoroughly cleaned by washing with water immediately before painting in order to prevent delamination of the paint film.

c) Time of surface preparation

Surface preparation shall be carried out immediately before painting. The first layer shall be finished within the specified time, as the surface to which the preparation has been carried out is susceptible to environmental influences, especially where steel surfaces have appeared, which react with oxygen and moisture in the atmosphere to produce rust in a short period of time. If the first layer cannot be finished due to sudden changes in the weather or other circumstances, the uncoated surfaces shall be reconditioned again.

d) Checking the surface preparation and the surface finish of the edges of the component

The surface to be painted shall be checked for a good degree of surface preparation and surface roughness, and that the required curved surface treatment of the edges of the component has been carried out properly.

The surface to be coated shall be thoroughly cleaned free of dust, sand, oil, grease and other harmful substances. If sea salt particles are thought to be adhering to the surface to be coated, the surface shall be thoroughly rinsed before painting.

Areas where painting is not to be carried out shall be masked to prevent paint from adhering to them.

2. Material preparation

a) Paint

Care and attention should be paid in handling of the material to ensure that its consistency and viscosity is maintained during transportation and storage. Expiry dates should be checked to ensure that the manufacturer's stipulated dates are complied with.

b) Mix proportions

The paint to be used shall be adjusted to the appropriate viscosity according to the painting method, the amount of paint applied and the temperature at the time of painting. In this case, if a diluent (thinner) is unavoidably used, the amount of the diluent shall be kept to a minimum, weighed accurately and added, and the diluent shall be from the same manufacturer as the paint. However, diluents shall not be used for solvent-free paints.

In cases where diluents are separate materials, care should be maintained as the mix proportions are being done to be consistent with proportions, weight requirements and consistency requirements.

In cases where mechanical agitations are required, surface of the agitators and agitation temperatures should be consistent with manufacturer's instructions.

c) Application timelines after mixing

Care should be observed on manufacture's timelines recommendations for application after mixing diluents. Diluent properties as specified by manufactures should inform painting timelines post mixing.

3. Repainting

a. Paint application

i On-site painting shall be based on brush application and airless spray application.

ii When multi-component paint mixtures are used, paint that has exceeded its pot life shall not be used. Wet paint shall be used as appropriate during painting.

iii Wet film gauges shall be used to control film thickness as necessary during the coating process. The correlation between wet film thickness (wet film thickness) and dry film thickness (dry film thickness) for each paint to be used shall be obtained from the paint manufacturer in advance.

b. Conditions prohibiting painting work

Coating shall not be carried out in the following conditions:

i Temperature and humidity must be in accordance with the coating standards.

ii In the case of outdoor painting, when it rains, snows or strong winds occur or are likely to occur.

iii When the painted surface is wet due to condensation, etc. and is expected to remain so.

iv When the surface temperature of the painted surface is below the temperature specified in proper criterion or above 50°C.

v When foreign matter is expected to adhere to the surface during drying (curing) of the coating film.

vi When the surface preparation is not carried out as specified.

vii When the specified intervals between coats have not been taken.

viii When mud, oil, grease, dust, etc. adhere to the painted surface.

ix If the paint used has exceeded the specified usable time.

x If the paint is not sufficiently mixed, agitated or diluted.

xi In other cases where the Engineer considers it inappropriate.

c. Coating intervals

The interval between coats shall be within the limits specified for each coating system. In this case, the coating shall be applied after the lower coating has sufficiently dried (hardened) and the coating has hardened and dried without causing any problems. In corroded areas, the surface of the steel material is activated after blasting and rusting occurs at an early stage (turning phenomenon).

Coating conditions of the surface to be coated

i Before the first layer of primer coating, the surface shall be freed from moisture, oil, grease, dust, rust, slag, abrasive, etc. as specified in the preparation.

ii For the second and subsequent layers of coating, it shall be ensured that the underlying coating is suitable for the layers to be painted over. In addition, there shall be no adhesion of moisture, oil, grease, dust, rust, slag abrasive, etc. and defects on the coating film.

d. Repainting

The painted surface shall be inspected after painting is completed and if there are any coating defects, the surface shall be repainted as soon as possible according to the Engineer's instructions.

e. Work control

i Work control items

A. The work management personnel are to control and record the following items.

B. Degree of surface preparation, elapsed time after surface preparation (conditions).

C. Condition of paint used, amount of paint used, storage of paint.

D. Coating work: Environmental conditions of the work, coating conditions of the coated surface, appearance of the coating, intervals between coats, thickness of the coating film.

E. Areas where surface preparation is not possible.

ii Confirmation of surface preparation

Observe the surface to check the degree of surface preparation as specified.

iii Condition of paints used

A. Paint to be used shall be within the date of manufacture and expiry date (generally within 1 year of manufacture).

B. After the paint cans have been opened, the condition of the paint shall be checked, including the state of the coating skin, colour separation, solidification (gel), separation and colouring.

C. For multi-component paint mixtures, the mixing ratio and whether the paint is used within the usable time after mixing.

D. Dilution of paints by diluent (thinner), the proportion and viscosity of the paint to be applied.

4. Curing

Paint layer shall be protected from debris and other contaminants after application in order to maintain smooth surface.

13207 MEASUREMENT AND PAYMENT

Item: Repaint of steel bearing

Unit: m^2

Measurement shall be in square meters.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for repainting steel bearing as detailed in plans and specifications.

13300: SLOPE PROTECTION WITH FOUNDATION SUPPORTED BY PILES

13301 SCOPE OF SECTION

This section covers reinstatement of damaged slope protection works around substructures. It involves placing a foundation beneath the damaged slope protection. The foundation is a concrete base supported with piles. The piles are driven to a minimum depth of 2.0 m. The foundation is placed at 1.0 m level below the river bed. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

13302 GENERAL

Damage to slope protection around substructures is often caused by scouring, rapid river flow, or improper construction and change in river course. In most of the damaged cases, foundation for the slope protection was not provided; hence, the protection eventually fails due to either sliding or scouring. Repair involves provision of appropriate foundation at its base.

13303 DEFINITIONS

The process under this section involves reinstatement of damaged substructures foundation caused by scouring, rapid river flow, or improper construction and change in river course among others.

13304 APPLICABLE STANDARDS

All materials required for the slope protection shall be in accordance with the provision of the relevant clauses of the following British Standard or Eurocode:

BS EN 1996	Masonry stones
BS 443	Testing zinc coatings on steel wire and for quality requirements
BS 812	Testing Aggregates: Methods for determination of particle size and shape
BS 1052	Specification for mild steel wire for general engineering purposes
BS EN 1992	Design of concrete structures

The material shall be approved by the Engineer through mill certificate of the supplier.

13305 MATERIALS

1. Stone Masonry
2. Cobble Stones
3. Sand Bags
4. Gravel
5. Gabion Mattress
6. Sheet Piles
7. Rock Fill Gabions
8. Concrete with minimum steel reinforcements
9. Filter Fabric Sheet (under gabion mattress)

13306 ORDER OF WORKS

1. Excavation of scoured area

The damaged section of the existing slope protection shall be demolished, and the scoured section excavated in accordance with the alignment and depth shown on the drawings. The limit of demolition shall be marked on the existing protection. After excavation, the bed surface shall be compacted using a lightweight mechanical or vibratory compactor.

2. Placing concrete foundation

Sheet piles shall be driven at an interval of 1.5 m. When driven depth is achieved, excess protruding length shall be cut. Concrete foundation, provided with minimum reinforcements shall be formed and casted above the piles. If river water exists, sand bags acting as cofferdam shall be provided during the foundation works.

3. Compaction of backfilled gravel

Natural slope surface shall be properly compacted. Gravel filling for the masonry base shall then be placed and compacted using lightweight mechanical or vibratory compactor. A thickness of more than 300 mm shall be placed in 2 layers at the slope base.

4. Placing masonry stones

Appropriate masonry stones shall be selected from the variety of slope protection works materials such as stone masonry, grouted riprap and concrete masonry.

5. Installation of gabion mattress and backfill with rock

After filter fabric sheet is spread tightly on the bed, gabion mattress shall be installed in front of the concrete foundation as protection against local scouring and sliding. Finally, the excavated area and voids around the protection structure shall be backfilled with cobble stones, up to the level of river bed.

13307 MEASUREMENT AND PAYMENT

Item: Excavation of scoured area

Unit: m^3

This work shall be paid based on a unit price per cubic meter for "Excavation of scoured area", complete in place, which shall include all materials, containers, equipment, tools, labour, services of the technical service advisor, and work incidental for the excavation of scoured area.

Item: Placing concrete foundation

Unit: m^3

This work shall be paid based on a unit price per cubic meter for "Placing concrete foundation", complete in place, which shall include all materials, containers, equipment,

tools, labour, services of the technical service advisor, and work incidental for the placing concrete foundation.

Item: Filling and compaction of gravel

Unit: m^3

This work shall be paid based on a unit price per cubic meter for "Filling and compaction of gravel", complete in place, which shall include all materials, containers, equipment, tools, labour, services of the technical service advisor, and work incidental for the filling and compaction of gravel.

Item: Placing masonry protection

Unit: m^2

This work shall be paid based on a unit price per square meter for "placing masonry protection", complete in place, which shall include all materials, containers, equipment, tools, labour, services of the technical service advisor, and work incidental for the placing masonry protection.

Item: Installation of Gabion Mattress and Backfill

Unit: m^3

This work shall be paid based on a unit price per square meter for " Installation of gabion mattress and backfill ", complete in place, which shall include all materials, containers, equipment, tools, labour, services of the technical service advisor, and work incidental for the installation of gabion mattress and backfill.

13400: GABIONS

13401 SCOPE OF SECTION

This section covers the construction of gabion walls, aprons, retaining walls, lining channels, revetments, bridge and culvert protection, protection of road embankments and other retaining structures.

All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

13402 GENERAL

The contractor shall carry out all the work as specified in this section unless otherwise directed by the Engineer.

13403 DEFINITIONS

Gabions are flexible galvanized steel wire and wire-mesh cages packed with boulder or cobble sized rock fragments and used to prevent erosion or retain slope.

Gabions consists of the following components:

Gabion mesh: A cage made of wire that is filled with rock to provide protection.

Binder wire: A thin wire that is used to connect two or more objects.

Filter Fabric: A geotextile material placed on the retaining face of the gabion to retain and minimise loss of fines from the retained earth through the gabion.

13404 APPLICABLE STANDARDS

The wire mesh used for gabion mattress shall be in accordance with the provisions of the relevant clauses of the following British Standard, Eurocode, Kenya Bureau of standards or equivalent ASTM Specification:

Gabion Mattress and Galvanised Wire

BS 1052	Specification for mild steel wire for general engineering purposes
BS 4483:2005	Gabion wire mesh apertures
BS EN 10244:2001	Wire Galvanizing
BSEN10223-3:1998	Elongation of the wires
BS EN 10223:1998	Tensile strength of wires
BS EN 10244:2009	Testing zinc coatings on steel wire and for quality requirements

Non-Woven Geotextile Filter Fabric

Test	**Test Standard**
Wide width strip tensile (KN/m)	BS EN ISO 10319:2008
Elongation (%)	BS EN ISO 10319:2008
CBR Puncture resistance (N)	BS EN ISO 12236:2006

Trapezoidal tear resistance (N)	ASTM D4533-04(2009)
Permeability -10 cm head (l/sqmxsec)	BS EN ISO 12958:1999
Pore Size (μm)	BS EN ISO 12956:1999

13405 MATERIALS

1. Rock fill

The broken hard and durable rock of 150mm minimum dimension and 300mm maximum dimension in compliance with the provisions of Clause 2602 of the Standard Specification for Road and Bridge Construction.

2. Gabion Mesh

The maximum mesh size shall be 60mm × 80mm. All wire shall be to BS EN 10223:1998 having tensile strength of not less than 40kg/mm^2. Galvanizing shall comply with the requirements of BS EN 10244:2001 and section 2600 of the Standard Specification for Road and Bridge Construction.

3. Filter Fabric Sheet

The geotextile filter fabric shall be polymer sheet of woven polypropylene of minimum sheet or non-woven. The fabric shall be inert to chemicals commonly encountered in sea water and natural soil conditions. The fabric sheet shall comply with section 2700 of the Standard Specification for Road and Bridge Construction.

4. Binder wire

Shall comply with the requirements of BS EN 10223 i.e., shall have a diameter of 2.2mm and tensile strength of not less than 40kg/mm^2. Galvanizing shall comply with requirements of BS EN 10244:2001.

5. Backfill Material

Shall be obtained from the material excavated in forming the excavation and in the event of there being an insufficient excavated material then selected backfill shall have a CBR of at least 5% measured after 4-day soak on laboratory mix compacted to 95% MDD and in compliance with Section 2600 of the Specification for Road and Bridge Construction.

13406 ORDER OF WORKS

Construction of gabions shall comply with the provisions of section 2600 of the Standard Specification for Road and Bridge Construction.

1. Preparing the foundation and surface

The surface on which the gabion cages are to be laid prior to being filled with rock shall be levelled and compacted to the depth shown on the drawings or as directed by the Engineer so as to present an even surface.

2. Filter fabric

One layer of grade 3 filter fabric shall be placed where indicated on the drawings or ordered by the Engineer. The material shall be placed in accordance with the specifications in strips with a minimum overlap of 300 mm at the joints and shall be properly fastened to prevent any movement or slipping while the gabions are being placed. The filter fabric shall not be left exposed to sunlight for more than 21 days.

3. Assembly

The methods of constructing, stretching, placing in position, wiring and filling the gabions with rock shall generally be in accordance with the manufacturer's instructions which shall be approved by the Engineer.

The joint of the gabion shall be stitched together with the binder wire, with at least one stitch per 50mm and each of the wire shall be fixed with at least two turns upon itself.

4. Rock filling

a) Boxes in retaining walls

Particular care shall be taken in packing the visible faces of gabion boxes where only selected stone of the specified size shall be used so as to obtain an even–faced finish. The boxes shall be filled in layers to prevent deformation and bulging. Boxes shall be filled to just below the level of the wire braces, after which the braces shall be twisted to provide tension. Care shall be taken to ensure that consecutive layers of cages are filled evenly to a level surface ready to receive the next course.

b) Mattresses used in revetments and aprons

The gabion mattresses forming aprons and revetments shall be filled by random stones being packed in the first layer and selected stones being used for the top layer so as to resemble normal stone pitching.

5. Backfilling

Unless otherwise instructed by the Engineer, the existing soil shall be backfilled, compacted against the sides of the gabions and extend to the limits of excavation or to natural ground.

6. Grouting

On completion of gabion construction, the exposed joints and top surface shall be grouted with mortar to the approval of the Engineer to discourage vandalism and damage as provided for under clause 11006 of this specification.

13407 MEASUREMENT AND PAYMENT

Item: Gabion mattress

Unit: Cubic meters (m^3) for gabion bed excavation;

Square meters (m^2) for the gabion mesh;

Square meters (m^2) for Filter Fabric.

Kilogrammes (Kg) for binder wire;

Cubic metres (m^3) for the stones,

Square meters (m^2) for grouting, and,

Square meters (m^2) for curing

Payment shall include full compensation for provision of materials, labour, tools, equipment and other necessary accessories to complete the works.

13500: SLOPE PATCHING

13501 SCOPE OF SECTION

This section covers removal of damaged masonry slope protection, topping up and compacting gravel filling and masonry patching/ repair. All repair work shall be performed in accordance with drawings, this specification and section 2500 of the Standard Specification on Road and Bridge Construction and Engineer's instruction.

13502 GENERAL

Slope patching is an effective method that can be adopted to repair the limited damages on the masonry, during the early stage of visible defects. Slope protection around the abutment is often damaged due to inadequate compaction of slope embankment, strong stream flow and insufficient flood drains.

13503 DEFINITIONS

Slope patching is the restoration/ repair of protection on embankment or slopes against failure. It involves furnishing of materials and the repair of a protective covering in stone masonry.

13504 APPLICABLE STANDARDS

All materials required for the slope protection shall be in accordance with the provisions of the section 2500 of Standard Specifications for Road and Bridge Construction.

Masonry Stones	BS EN 1996
Cement	KS EAS 18-1
Sand	AASHTO M6-08/ KS EAS 1609:2001
Water	KS EAS 12:2014

13505 MATERIALS

1. Masonry stones
2. Cement
3. Sand
4. Gravel
5. Water

The materials shall be in accordance with the provision in the specifications and approved by the Engineer.

13506 ORDER OF WORKS

1. Removal of damaged protection

The damaged section of the existing slope protection shall be removed, and the scoured section excavated in accordance with the alignment and depth shown on the drawings. The limit of removal shall be marked on the surface of existing protection. After excavation, the bed surface shall be compacted using a vibratory compactor.

2. Fill and compact gravel

Natural slope surface shall be properly compacted. Gravel filling for the masonry base shall then be placed and compacted using a vibratory compactor. A thickness of more than 300 mm shall be placed in 2 layers at the base of the slope.

3. Patching

Approved masonry material shall be laid on the prepared surface in the same pattern as that of the existing masonry and joints shall be filled in accordance with the Engineer's specifications.

4. Curing

Continuous curing using wetted cloth mat shall be done to mitigate drying shrinkage. Curing shall be carried out in accordance with the specifications.

13507 MEASUREMENT AND PAYMENT

Item: Slope patching

Unit: Cubic meters (m^3). For removal of damaged masonry.

Cubic meters (m^3) for gravel fill and compaction.

Square meters (m^2) for Stone masonry patching.

Square meters (m^2) for curing

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for slope patching as detailed in plans and specifications.

13600: NYLON FIBRE GABION

13601 SCOPE OF SECTION

This section covers formation of gabions through placing boulders into fibre bags formed by knitting nylon fabric, transportation to scoured area and placement.

13602 GENERAL

The nylon fiber gabion is flexible and conforms to the shape where it is placed. The nylon netting allows water passage through bag body ensuring that pressure of flowing water does not affect the bag. As such, nylon fiber gabion is used for prevention of scour on pier foundation and other underwater structures where the river bed shape is complicated and gabion mattresses are difficult to install.

13603 DEFINITIONS

Nylon fibre gabions refers to a type of scour protection method formed by placing boulders into fibre bags formed by knitting nylon fabric. The bag is filled with boulders or stones which are also used for conventional box-type zinc-coated wire gabions They are preferred where the river bed is complicated and flexibility of the gabion is required.

13604 APPLICABLE STANDARDS

The nylon fibre gabion bag materials shall be in accordance with the following standards:

1. Tensile Strength

ASTM D4268, BS 8002:2015	Netting (25 mm mesh size)
ASTM D4268, BS 8002:2015	Hanging Rope (9mm Ø)
ASTM D4268, BS 8002:2015	Top Tie Rope (6mm Ø)
ASTM D4268, BS 8002:2015	Bottom Tie Rope (6mm Ø)

2. Elongation

ASTM D4268, BS 8002:2015	Netting (25 mm mesh size)
ASTM D4268, BS 8002:2015	Hanging Rope (9mm Ø)
ASTM D4268, BS 8002:2015	Top Tie Rope (6mm Ø)
ASTM D4268, BS 8002:2015	Bottom Tie Rope (6mm Ø)

13605 MATERIALS

1. Nylon Fiber Gabion
2. Knitted fabric material
3. Rock Fill (Boulders)
4. Backfill Materials

The materials shall be in accordance with the provision in the specifications and approved by the Engineer

13606 ORDER OF WORKS

1. Bed preparation

The scoured area shall be excavated and trimmed to the specified level and shape in accordance with the provided drawings or as instructed by the Engineer. The surface upon which gabions shall be laid shall be compacted as instructed by the Engineer.

2. Placement of boulders into nylon fibre gabion bag

The broken hard and durable rock of 150mm minimum dimension and 300mm maximum dimension in compliance with provisions of clause 2602 of the standard specification for road and bridge construction shall be used. When filled, nylon fiber gabion shall weigh 2 tonnes with equivalent size of 3m x 2m and volume of about 1.24m^3.

3. Transportation to scoured area

After filling with boulders, nylon fibre gabion shall be transported to scoured area by mechanical means (backhoe).

4. Placement of nylon fiber gabion bags on scoured area

The gabions shall be laid using a backhoe into the scoured portion to designated elevation. Gabion-to-gabion joints shall be tightened every 1m with nylon wire of the same standard as that used for the gabion. In the case of installing stop girders, the gabion shall be properly installed and casted so that it is fixed to the slope and has the sectional shape specified in the design documents.

13607 MEASUREMENT AND PAYMENT

Item: Nylon fibre gabion

Unit: m^3

Measurement shall be in cubic meters.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for nylon fibre gabion as detailed in plans and specifications. Any other items of work not covered in this shall be determined by the Engineer.

13700: SCAFFOLDING

13701 SCOPE OF SECTION

Scaffolding elevates workers to a height that can facilitate ease of work and protect workers, tools and materials from falling below

13702 GENERAL

Scaffolding is necessary where a work at height of more than 1.8m is required

13703 DEFINITIONS

Scaffolds: Temporary structure that is typically made from metal poles and wood planks and erected to support construction workers, inspectors, cleaners and others who need to work at height.

Platform: Any temporary elevated or suspended work surface used to support workers and/or materials

Railing: It is a temporary edge protection to scaffolding structures.

13704 APPLICABLE STANDARDS

BS 1139

EN 39

13705 MATERIALS

1. Aluminium
2. Stainless steel
3. Steel
4. Wood
5. Other proprietary materials

13706 ORDER OF WORKS

1. Site preparation.

Familiarize with the site conditions by establishing the heights and terrain to be scaffolded.

2. Erection of scaffold.

Ensure the scaffold is based on a firm, level foundation. The ground or foundation must be capable of supporting the weight of the scaffold and any loads likely to be placed on it.

3. Inspection of scaffolds.

Before using any scaffold, make sure that it is safe and suitable for the intended purpose. A complete scaffold field inspection checklist shall be used.

A scaffolding tagging system is required to allow all users to observe current status of the scaffold. It shall consist of a holder and inserts which are signed by the inspector.

4. Platform movement.

Safety should be observed as platform is moved from one height level to the other observing the safety of tools, workers and personnel.

5. Dismantling of scaffolds.

Dismantling shall begin from the top of the scaffold. Scaffold ties shall not be removed until the scaffold above them has been completely disassembled to the tie level. A sufficient space shall be created to neatly store the components.

13707 MEASUREMENT AND PAYMENT

Item: Scaffolding

Payments are deemed to be included in the unit rates of the work items.