



STANDARD SPECIFICATION FOR BRIDGE REPAIR IN KENYA

EDITION 1



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



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DOCUMENT MANAGEMENT

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This document has the status of a Manual. Users shall apply the contents there-in to fully satisfy the requirements set out.

The content of the specifications is based on current practice in Kenya and latest practices in the road sector – locally, regionally and internationally.

Notification of errors and requests for amendments:

While all care and consideration has been applied in the compilation of this document, the Ministry accepts no responsibility for failure in any way related to the application of the specification or any reference documents cited in it.

Requests for edits and corrections can be freely sent to the following address:

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FOREWORD

The Government of Kenya through its Vision 2030, Kenya's long-term development strategy aimed at transforming the country into a middle income country, has prioritized infrastructure as a foundational enabler of the economic recovery strategies to re-position the economy on a steady and sustainable growth trajectory. In the 4th Medium Term Plan (2023-2027) of the Vision 2030, priority for an increased investments in improving infrastructure so as to lower the cost of doing business and improve national competitiveness and productivity have been identified as core themes for infrastructure development and management.

With full implementation of Performance Based Contracting (PBC) and continued funding from RMLF, there has been tremendous improvement in road maintenance in the Country. However, not enough attention has been paid to having a structured program that deals with maintenance of highway structures. Thus, the Bridge Management System (BMS) project was initiated to address management and repair of structures in Kenya. This is particularly important, as the structures form an integral part of the road network.

These specifications give the implementation guidance for bridge maintenance and repair works. The specifications has delineated the scope of works to be undertaken under each work item, defined the extents and breakdown the considerations to be made, key elements for consistency, proposed a standard order of work in line with best practice and a measurement and payment considerations.

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

These specifications were developed by the Bridge Repair Sub-Working Group, constituted under the State Department for Roads with the assistance of the Japan International Cooperation Agency (JICA), through the BMS project. The membership of the sub-working group was drawn from SDR, MTRD, KeNHA, KURA, KeRRA, KRB, KWS, NCA and Japanese experts, whose contribution and dedication towards the development of this manual is acknowledged with appreciation.

We are particularly grateful to the JICA team for their continued support to the Roads Subsector and in particular, their technical assistance towards the development of this manual.



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Kenya Roads Board (KRB)
Kenya National Highways Authority (KeNHA)
Kenya Rural Roads Authority (KeRRA)
Kenya Urban Roads Authority (KURA)
Kenya Institute of Highways and Building Technology (KIHBT)
National Construction Authority (NCA)
Materials Testing and Research Directorate (MTRD)
Kenya Wildlife Service (KWS)

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10100: GENERAL

10101 DEFINITION OF TERMS AND ABBREVIATIONS

Abutment	Structural members located at both ends of a bridge that connects the embankment portion of the approach road to the bridge. It supports the load from the superstructure and retains the earth material.
Annealing	This refers to a heat treatment process used to modify the properties and structure of steel to improve its ductility, toughness and reduce internal stresses.
Annual Bridge Maintenance Action Plan	This is an asset management plan that contains bridge maintenance interventions, budget allocations and responsibility assignments within a road network. This plan should be structured in the format proposed in the ISO 55000.
Approach slab	It is a concrete slab installed behind the abutment that acts as an intermediate bridge to avoid abrupt changes in elevation or alignment.
Backwall/Curtain wall	The vertical wall at the ends of abutments that extends up from the bearing seat and supports the approach slabs, expansion joints and the embankment under the approach slabs.
Bearing	It is a device which transmits the vertical and horizontal actions from the superstructure to the substructure, and allows for movements between the superstructure and the substructure. Bearings allowing both rotation and longitudinal translation are called expansion/movable bearings, and those, which allow rotation, only are called fixed bearings.
Bridge	A structure, that can be accessed by traffic, with the function of aiding crossing over a waterway, road or any other obstacle. In the context of this manual, it also includes box culverts, viaducts and tunnels.
Bridge component	A bridge component is one of the three i.e. Principal Structure, Non-Structural Elements (NSE) and Road Furniture.
Bridge element	A bridge element is a part that acts to provide functionality, durability and safety requirements of a bridge which includes: superstructure, substructure or ancillary parts.
Coating	A layer applied to bridge elements to prevent corrosion and negative environmental effects.
Contractor	The entity engaged by the Employer through a due contract for the implementation of a supply, maintenance and/or repair assignment.
Corbel	It is a projecting wall member used as a support for some elements of the superstructure.
Cutback	A mixture of miscible liquids (petroleum and bituminous based liquids) used in construction, repair and maintenance of roads and bridges.
Damage	Defects due to external forces, e.g., flood, vehicle load, vehicle collision, earth pressure, vandalism etc.

Deck slab	A structural member that directly supports traffic passing through a bridge and transmits the load to the main girder (main structure).
Design working life	An assumed period for which a structure or part of it is to be used for its intended purpose with anticipated maintenance but without major repair being necessary.
Deterioration	Defects caused by changes in condition with age, e.g., carbonation, Alkali-Silica Reaction (ASR), salt damage etc.
Diaphragm	It is a bracing that connects main girders at the supports, to resist lateral actions and transfer loads to the supports. It locks the girders in place and also provides support to the deck slab.
Employer	The Employer is the procuring entity responsible for the road network in Kenya and who enters into a road/bridge maintenance contract with a contractor on a certain section of the road.
Emulsion	A mixture of immiscible liquids (water and bituminous based liquids) used in construction, repair and maintenance of roads and bridges.
Engineer	The representative of the Employer with responsibilities and obligations under the maintenance contract.
Environmental Management Plan	A plan developed to mitigate environmental impact of bridge maintenance activities in compliance to NEMA regulations.
Epoxy	A type of polymer that when exposed to heat or chemical reactions hardens forming a compound with desirable engineering properties like adhesion, chemical and heat resistance, hardening, waterproofing and electrical insulation.
Expansion gap	A gap provided between a bridge girder and abutment or between discontinuous girders to allow expansion and contraction due to temperature changes.
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. It is mainly made of steel or rubber.
Foundation	The part of the substructure that transmits loads to the ground. Depending on the form, there are different types of foundations such as spread footing, pile foundations, and caisson foundations, etc. It transmits the loading from the substructure to the ground.
Implementers	The organizations involved in the inspections and maintenance/repair of bridges. In maintenance of bridges, the implementers are the road agencies, engineering consultants and contractors engaged in the construction, repair and maintenance of structures/roads.
Initial defects	Anomalies which were caused by design and/or occurred during construction (poor workmanship).
Input	Labour, materials, equipment and other supplies required to carry out the works.

Life Cycle Cost	This is an estimate of the cost that will be undertaken from the selected option of a structure or repair option during its service life. It includes the cost of planning, purchase, installation, operation, maintenance and decommission at the end of the structure service life.
Limit States	States beyond which the structure no longer fulfils the relevant design criteria.
Main girder/ Main structure	The main part of the superstructure, the structural member that supports all the loads acting on the bridge. In general, it is called the main girder in the case of girder structure, and the main structure in the case of truss or arch structure, etc.
Maintenance	The actions taken to keep the condition of a structural element to perform to its level of service.
Mobilization Period	The period required for the contractor to mobilize labour, equipment and materials for the commencement works.
Ninja-tech	The use of straps, ropes and other safety harness to inspect and undertake minor repairs underside of bridge and other hard to reach bridge members.
Obstructions	Accumulation of debris, driftwoods and stumps, rocks, silt, animals or anything that may impede free flow of water through a structure.
Painting	A layer of material applied on bridge elements for protective and/or aesthetic purposes.
Pier	A substructure member which supports the superstructure at intermediate points and transmits the load to the foundation.
Piles	A series of columns constructed into the ground transmitting loads down from the substructure for adequate support.
Policy Formulators	These shall be persons/entities responsible for making policies towards bridge repair and bridge maintenance.
Polymer	This is a long chain molecule made up of many repeating units. Polymer is added to mortar to improve the mortar performance.
Polymer Cement	Binders, compounds and aggregates mixtures that use epoxies, polyesters, vinyl-esters or other polymer resin bonds.
Polyurethane	This is an organic polymer that features many organic units linked via urethane molecules. Polyurethanes, often abbreviated to PU or PUR, are an immensely versatile class of polymers used in insulators, foams, elastomers, synthetic skins, coating and adhesives.
Rating Scale	This is a five stage condition status indicator for bridge elements as inspected. Deterioration rating shall be based on location, severity and element importance. This shall be assigned after detailed inspection.
Repair	This is the reinstatement of a damaged member or structure to its designed or as-built condition.
Safety Officer	Officer responsible for planning, implementing and overseeing health and safety on site.

Scaffolding	Temporary raised platform used to support workers, equipment and materials during construction works when the area being worked on is high/hard to reach from floor level.
Serviceability Limit States	States that correspond to conditions beyond which specified service requirements for a structure or structural member are no longer met.
Stakeholders	Person(s) with interest in the use and maintenance of bridges. They include the road agencies, engineering consultants, contractors, road users and the communities affected by the presence and usage of the bridge.
Stress relief annealing	An after treatment procedure of cast with the aim to reduce inner stress within the castings.
Substructure	Structural members that transfer the load from the superstructure, through the bearings, to the ground. It is a general term for bridge abutments, piers, and foundations.
Superstructure	Supports the weight of objects passing through the bridge and transmits it to the substructure. It consists of main girder, deck slab, cross beam, lateral bracing, diaphragms, etc.
Timber	Processed wood that is suitable for building of structures.
Ultimate Limit State	States associated with collapse or with other forms of structural failure.
Value Management	Value management is the technique concerned with maximisation of limited resources to achieve value for money.
Wingwall	The sidewall to the abutment backwall which is provided for to assist in confining the earth behind the abutment. The wingwalls can be monolithic with the backwall or disjointed.
Works	Combination of materials, skill and manpower and or equipment systematically executed as per the described methodology and in accordance with the Specifications for construction, repair, maintenance, strengthening, re-instatement and decommissioning of bridges.

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
KEBS	Kenya Bureau of Standards
KS	Kenya 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 be in accordance with Section 1900 of the current edition of Specification for Roads and Bridge Construction or as specified by the Engineer.

For specific components allowances for installation tolerance shall depend on: existing standards, manufacturer's specifications and situational or environmental considerations.

10107 HOW TO USE THE SPECIFICATIONS

The standards used in this specification shall comply with the 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.

Contractors' staff executing bridge repair works shall have adequate training on bridge management by accredited trainer and registered by NCA.

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

Bridge cleaning shall consist of removal of all accumulated foreign materials from the entire bridge or bridge sections including but not limited to bridge deck, sidewalks, kerbs, pier caps, trusses, truss members, girders, expansion joints, and piers.

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: m²

The work shall be paid on a unit price per square meter for cleaning.

The rate for cleaning shall include full compensation for materials, containers, equipment, tools, labor and work incidental for cleaning.

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 painting 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 provided 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, equivalent British Standard or Eurocode:

ASTM-D1730, BS 3900-F20: 2004	Standard Practices for Preparation of Aluminium and Aluminium-Alloy Surfaces for Painting
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10305 MATERIALS

1. Aluminium Paint (locally available)
2. Thinner
3. Anti-corrosion Paint
4. Any other equivalent material approved by the Engineer.

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.

i. *Preparation for painting operations*

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

ii. *Paint application*

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

- b. 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.
- c. 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:

- i. Where temperature and humidity are not in accordance with the coating standards.
- ii. In the case of outdoor painting; when it rains, 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 and deleterious materials 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.

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:

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

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

- i. 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.
- ii. Workability: The paint should flow freely despite the prevailing environmental conditions.

10. Conditions of the surface to be coated

- i. 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.
- 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 no defects in the coating film.

10307 MEASUREMENT AND PAYMENT

Item: Touch-up painting

Unit: m²

The work shall be paid on a unit price per square meter for touch-up painting.

The rate for touch-up painting shall include full compensation for materials, containers, equipment, tools, labor and work incidental for touch-up painting.

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 a leaking slab, waterproofing shall be done first 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 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: m²

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: PLASTERING

10501 SCOPE OF SECTION

This section covers removal of loose debris, furnishing formwork, coating bonding agent or setting nail, plastering 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. Plastering 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.

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

10503 DEFINITION

Plastering is the repair to damaged area with approved technique and method.

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.

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

- i. Pre-mixed and pre-bagged Portland Cement Mortar
- ii. Water
- iii. Concrete nail
- iv. Bonding agent to concrete (Epoxy Bonding)

2. Polymer Cement Mortar (PCM)

- i. PCM powder
- ii. PCM emulsion
- iii. Concrete nail
- iv. Bonding agent to concrete (Epoxy Bonding)

3. Any other equivalent material approved by the Engineer.

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

10506 ORDER OF WORKS

1. Cleaning concrete and rebar surfaces

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. Rust 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 between 13mm for a single layer to 20mm for two layers thick. Each layer shall be compacted over the entire surface using a wooden trowel or hammer. Generally, there should be no time delays between the placing and compacting of layers.

4. Curing

All the plastered sections shall be cured for a minimum of 7 days to gain strength and to minimize drying shrinkage. Curing method shall be as per the Engineer's instructions and manufacturer's specifications.

10507 MEASUREMENT AND PAYMENT

Item: Plastering

Unit: m²

Measurement shall be square meters for depth less than 50mm calculated as the area 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 plastering 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 and traffic 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 shall be made for breaking the boulders 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 – Assessment shall be made on the nature and type of other materials blocking the openings and appropriate removal mechanism device shall be applied for ease of removal and disposed to approved site by the Engineer.

10607 MEASUREMENT AND PAYMENT

Item: Removal of obstructions from structures openings

Unit: m³

The work shall be paid on a unit price per cubic meter for the removal of obstructions from structures openings.

The rate for removal of obstructions from structure openings shall include full compensation for materials, containers, equipment, tools, labor and work incidental for the removal of obstructions from structure openings.

**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 proposed for use in 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 0.01m³. 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 the specified time from the date of manufacture.

3. Fine aggregates (Sand)

Fine aggregates for mortar shall be clean, hard and durable and shall be river sand, pit sand and quarry 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.

5. Any other equivalent material approved by the Engineer.

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, 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 the already laid unit, the sitting mortar shall be removed, surface cleaned and fresh new mortar applied for final placement. Coursing and mortar joints shall be done in accordance with the Engineer's instructions.
4. 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 achieve 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: m²

The work shall 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 partial replacement of stone masonry 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 with thickness and appropriate coating as approved by the Engineer 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 with the following British Standard or equivalent Eurocode:

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/mm². The maximum mesh size shall be 100mm × 120mm. Galvanizing shall comply with the requirements of BS 443/BS EN10244-2. 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/mm². 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/m².

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.

4. Any other equivalent material approved by the Engineer.

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/mm².
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: m² and m³

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 partial replacement of gabion wire mesh and stone 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 static cracks in concrete structure using epoxy material.

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
4. Any other equivalent material approved by the Engineer

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 loose 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

11001 SCOPE OF SECTION

This section covers patching which involves 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.

11003 DEFINITION

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

11004 APPLICABLE STANDARDS

Portland Cement Mortar shall be in accordance with the provisions of the relevant clauses of Standard Specification 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, Eurocode 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 Eurocodes or equivalent ASTM Specification:

ASTM D695M, BS EN 13733	Compressive Strength
ASTM D790M, BS EN 13733	Flexural Strength
ASTM D638M, BS EN 13733	Tensile Strength
ASTM D1002, BS EN 13733	Tensile Shear Bond to Steel
ASTM C882, BS EN 13733	Slant Shear Bond to Mortar
ASTM D7234, BS EN 13733	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 provided.
2. Polymer Cement (PCM Powder, PCM Emulsion)
3. Concrete nail
4. Bonding agent to concrete (epoxy bonding)
5. Or any other equivalent material approved by the Engineer.

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 for a minimum of 7 days 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 external forces and vandalism.

11007 MEASUREMENT AND PAYMENT

Item: Patching

Unit: m³

Measurement shall be based on cubic meter for the volume of patching.

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 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 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 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 applied to ensure that it performs to its full potential. In addition, the repair material shall be cured and shall not be applied under construction conditions or other conditions that may lead to a reduction in strength. This shall be 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 away from 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
4. Or any other equivalent material approved by the Engineer

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 a 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 fibre 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 the 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 (CFS).

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. Adhesion resins

The resin shall be able to impregnate carbon fibres to improve bonding 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 by travelling vehicles, special protective works shall be considered separately as directed by the Engineer.

6. Or any other equivalent material approved by the Engineer.**MATERIALS PROPERTIES**

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

1. Ingredients of the base and hardening materials
2. Mixing ratio (by weight)
3. Specific gravity (hardened material)
4. Viscosity (mixture)
5. 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: m²

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 of steel plate bonding: injection method and pressure attachment 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 attachment 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.

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.

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 attachment 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 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.

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.

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)

The material shall be approved by the Engineer.

11305 MATERIALS

1. Steel plate
2. Primer (Epoxy Base)
3. Epoxy resin adhesive for injection
4. Epoxy sealant
5. Anchor bolts
6. Wood and angle for fitting
7. Or any other equivalent material approved by the Engineer

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

11306 ORDER OF WORKS

1 Injection Method

i. 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.

ii. 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.

iii. *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.

iv. *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.

v. *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 attachment method

i. *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.

ii. *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.

iii. *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.

iv. *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: m²

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 SLAB 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
BS 8110	Reinforced concrete design for structural concrete

11405 MATERIALS

1. Ordinary 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)
8. Or any other equivalent material approved by the Engineer

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. Use

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 rebar shall be cut up to the required lap length. New bars shall be provided 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 during execution 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 cases, 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/m³ 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 F1, F2 or F3 in accordance with Standard Specification of Road and Bridge Construction to match the adjacent existing concrete approved by the Engineer.

8. Curing and removal of formwork

Water curing with wetted cotton mat shall be done for a minimum of 21 days to slow down drying. Formworks for load bearing structural members shall remain in position until 80% of the 28 days compressive strength of the new concrete is achieved.

11407 MEASUREMENT AND PAYMENT

Item: Partial deck slab replacement

Unit: m³ for concrete, tonnage for steel and m² for formwork

Partial deck slab replacement shall be done in accordance with the plans and specifications and shall be measured in cubic meters for concrete, tonnage for steel and square meters for formwork used. 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 described 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, 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 ingress of water.

11503 DEFINITIONS

Concrete water proofing is the application of impervious material layer on concrete which make the structure watertight 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.

11505 MATERIALS

1. Rubberized membrane method
 - i. Primer
 - ii. Rubberized Membrane (2nd layer ~ 4th layer)
 - iii. Tack Coat (Finish Coat)
2. Asphalt compound method
 - i. Primer
 - ii. Asphalt Compound Membrane
 - iii. Silica sand No.4
3. Or any other equivalent material approved by the Engineer.

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

- a) Care shall be taken when milling the 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 surface using a roller brush. The coating shall be applied at a rate of approximately 0.2 kg/m² and naturally dried for more than 30 minutes until tack-free as per the manufacture's instructions.

3. 2nd Layer (Base coat)

Base coat, the 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/m².

4. 3rd Layer (Intermediary coat)

Intermediary coat, the 3rd layer, is a rubberized membrane which shall be applied on the base coat using a roller brush, to form a uniform film with equal thickness. Application rate of 0.4 kg/m².

5. 4th Layer (Top coat).

Top Coat, the 4th layer, is a rubberized membrane which shall be applied on the intermediary coat using a roller brush to form a uniform film with equal thickness. Application rate of 0.4 kg/m².

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/m².

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 Specification 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 surface. The surface 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/m² 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/m² 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 a rate of 3.0 kg/m² in accordance with 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 Specification for Road and Bridge Construction.

11507 MEASUREMENT AND PAYMENT

Rubberized membrane method

Item: Waterproofing on deck slab (Rubberized membrane method)

Unit: m²

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

Asphalt compound method

Item: Waterproofing on deck slab (Asphalt compound method)

Unit: m²

Waterproofing works shall be measured and paid per square meter computed as the product of length and width of the section works have been executed. The rate shall 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 replacement with fast setting concrete.

11603 DEFINITIONS

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

11604 APPLICABLE STANDARDS

Fast setting concrete 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)
7. Or any other equivalent material approved by the Engineer

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. Preparatory works

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 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 the 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 sections of existing concrete. Fast-setting concrete shall be poured within the recommended hardening time of epoxy resin.

6. Wet the formwork

After cleaning the inner side of the formwork, water shall be sprinkled to keep the surface wet 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 using appropriate means as shall be approved by the Engineer.

11607 MEASUREMENT AND PAYMENT

Item: Fast setting concrete for continued deck slab

Unit: m³

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 cause 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
3. Or any other equivalent material approved by the Engineer

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 deteriorated 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 direct 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 the 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 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 a trowel and/or a brush.

5. Curing

Water shall be sprinkled on the patched surface continuously for 3 days or as directed by the Engineer.

11707 MEASUREMENT AND PAYMENT

Item: Protective mortar

Unit: m²

The work shall be paid on a unit price per square meter for the applied protective mortar.

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

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 ingress 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 ₂ SO ₄)
ASTM D6943, BS 5493:1977	Alkali Resistance (5% NaOH)

11805 MATERIALS

1. Base Resin
2. Hardener
3. Or any other equivalent material approved by the Engineer

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 deteriorated areas shall be done using a disk sander or by 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 direct 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 the material.

3. Mixing acryl urethane protective coating materials

The base resin and hardener shall be mixed at a ratio of 1:4 by weight, 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. The minimum interval time between the application of the first and the next coats is 3 hours. One to three coats shall be applied.

11807 MEASUREMENT AND PAYMENT

Item: Protective coating

Unit: m²

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.

11900: RECASTING CONCRETE

11901 SCOPE OF SECTION

This section covers removal of deteriorated concrete, preparation of concrete surface and rebar, cutting of deteriorated rebar and adding new rebar, setting formworks, placing of concrete, 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 section after treatment of the corroded rebars.

11903 DEFINITIONS

Recasting method involves casting of concrete in the damaged area, by placing concrete onto 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 Eurocode 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
6. Or any other equivalent material approved by the Engineer

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 from 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 is 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 rebars shall be cut. 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 hose 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, m³ and m²

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 enhance flexural and shear reinforcement of concrete bridges.

12003 DEFINITIONS

Carbon fibre is a weaved mat of fibres 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 Fibre 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.

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 Fibre Plate Weight
ASTM D3039, BS ISO 14127:2008	Tensile Strength
ASTM D7234, BS EN 1504-4	Bond Strength to Concrete

The tensile strength test of the carbon-fibre plate material shall be applied in accordance with the Engineer's approval.

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 Fibre Plate & Concrete

The material shall be approved by the Engineer.

12005 MATERIALS

1. Carbon fibre sheet method
 - i. Carbon fibre sheet
 - ii. Carbon fibre sheet strip
 - iii. Epoxy primer
 - iv. Epoxy putty
 - v. Epoxy resin
2. Carbon fibre plate method
 - i. Carbon fibre plate
 - ii. Epoxy primer

- iii. Epoxy putty
 - iv. Epoxy resin
3. Or any other equivalent material approved by the Engineer.
- 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

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

3. Adjustment of unevenness

Any unevenness on the concrete surface shall be smoothed using epoxy putty. Flatness of concrete surface affects 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 a 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 then be pressed using a 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 the 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**

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 strengthen the surface of the existing concrete and improve adhesion to the carbon fibre sheet. The primer shall be applied on a dry concrete surface. The primer shall not be applied when the 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. The flatness of the concrete surface determines the adhesion of the carbon fibre plate, care shall be taken to ensure flattening of formwork joints and removal of air holes that cause the plate 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 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: m²

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: JACKETING 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 and equivalent Eurocodes:

BS 8110, EN 1992-2	Reinforced concrete design
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12105 MATERIALS

1. Cement and admixture (Silica fume)
2. Aggregates
3. Rebars
4. Water
5. Super plasticizer
6. Or any other equivalent material approved by the Engineer

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.

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

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

The minimum cover of the 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, shall 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 the Engineer's satisfaction.

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

5. Curing concrete

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

12107 MEASUREMENT AND PAYMENT

Item: Jacketing with concrete

Unit: Ton, m³ and m²

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 grades;

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 corrosion is stopped.

12204 APPLICABLE STANDARDS

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

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

The surface preparation for 2nd grade repainting 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, scales, 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 3 rd coat as intermediate coat
ASTM D16, BS 3900	Polyurethane Paint (SSPC-Paint No.36) for 4 th 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
4. Or any other equivalent material approved by the Engineer

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

12206 ORDER OF WORKS

1. Surface preparation

i. *Preparation for paint removal*

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

ii. *Preliminary adjustment*

In the case of dust adhesion or salt adhesion of 50 mg/m² or more, the surface shall be cleaned with fresh water immediately before painting in order to prevent delamination of the paint film.

iii. *Time of surface preparation*

Surface preparation shall be carried out before painting to the approval of the Engineer. 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.

iv. *Inspection of the surface prepared and finishing of the edges of the member.*

The surface to be repainted shall be inspected 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.

Sections not to be repainted shall be masked to prevent paint from adhering to them.

2. Material preparation

i. 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.

ii. 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 to ensure the mix proportions are consistent with the weight and consistency requirements.

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

iii. Application timelines after mixing

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

3. Repainting

i. Paint application

- a. On-site painting shall be based on brush and airless spray application.
- b. 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.
- c. 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.

ii. Conditions prohibiting painting work

Coating shall not be carried out in the following conditions:

- a. In the case of outdoor painting, when it rains, snows or strong winds occur or are likely to occur.
- b. When the surface to be painted is wet due to condensation, etc. and is expected to remain so.
- c. When the surface temperature of the surface to be painted is below the temperature specified or above 50°C.
- d. When foreign matter is expected to adhere to the surface during drying (curing) of the coating film.
- e. When the surface preparation is not carried out as specified.
- f. When the specified time intervals between coats have not been taken.
- g. When mud, oil, grease, dust, etc. adhere to the painted surface.
- h. If the paint used has exceeded the specified usable time.
- i. If the paint is not sufficiently mixed, agitated or diluted.
- j. In other cases where the Engineer considers it inappropriate.

iii. *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

- a. 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. In addition, there shall be no adhesion of moisture, oil, grease, dust, rust, slag abrasive, etc. and no defects in the coating film.

iv. *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.

v. *Quality control*

a. Quality control items

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

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

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

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

Areas where surface preparation is not possible.

b. Confirmation of surface preparation

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

c. Condition of paints used

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

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.

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

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 web plate, near the bearing of the bridge.

12207 MEASUREMENT AND PAYMENT

Item: Repainting.

Unit: m²

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 and angular plates, 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 members to restore the original designed strength.

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 Fibre Plate and Concrete

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

12305 MATERIALS

1. Flat and angular plates
2. High Tension Bolts (HTB)
3. Epoxy putty
4. Or any other equivalent material approved by the Engineer

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 12200 of this specification 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 fastened with electric fastener.

5. Epoxy caulking

Gaps 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 PLATE BONDING

12401 SCOPE OF SECTION

This section covers furnishing and installation of carbon fibre plates and adhesive resin such as epoxies to enhance the load bearing 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 fibre plate weight
BS 7658-1	Carbon fibre 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 Eurocode or equivalent ASTM Specifications:

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 Fibre 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 (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 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.

6. Or any other equivalent material approved by the Engineer.

12406 ORDER OF WORKS

1. Preparation of steel surface

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 plate shall be marked on the steel surface to ensure straightness of the carbon fibre plate.

2. Application of epoxy primer

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

Ensure that the steel surface is dry when applying the primer so that its function is not impaired. As a general rule, construction shall 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 smoothed 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: m²

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: REPLACEMENT OF HIGH-TENSION BOLTS

12501 SCOPE OF SECTION

This section covers replacement of missing and removal of severely corroded high-tension bolts.

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-tension bolts to fall off.

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, Eurocode 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
5. Or any other equivalent material approved by the Engineer

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 existing 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

- i. Primary tightening shall be carried out on all bolts by rotating the bolt at the appropriate torque value.
- ii. 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.
- iii. Main tightening shall be carried out by rotating the bolt 120° starting from the marking after the 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 $120^{\circ} \pm 30^{\circ}$ 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

- i. As a rule, all bolts shall be inspected in the presence of the supervisor to ensure that the required rotation angle has been obtained based on the markings after primary tightening.
- ii. The acceptable bolt rotation angle shall be $\pm 15^{\circ}$ of the specified rotation angles.
- iii. High-tension bolts with excessive amount of rotation shall be replaced.
- iv. High-tension bolts with insufficient turnover shall be retightened to the required turnover.
- v. Once used, high-tension bolts shall not be re-used.

12507 MEASUREMENT AND PAYMENT

Item: Replacement 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 saline environment, subjected to saline air and 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, 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/m² 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 Section 7900 painting in structural steelwork" of Standard Specifications for Road and Bridge Construction.

1. Emulsion
2. Compound
3. Or any other equivalent material approved by the Engineer

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 the 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 contained 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 between emulsion and compound shall be in accordance with the manufacturer's specifications.

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 done in accordance with 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.

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

Painting shall be carried as specified in Section 12200 of this specification.

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 dries within a day under room temperature of 25°C. During rainy season, drying time may extend. 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 as per the specifications and as approved by the Engineer.

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: m²

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 DEFINITION

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
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The flexible asphalt shall be in accordance with the provisions of the relevant clauses of the following Eurocode 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.

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
5. Or any other equivalent material approved by the Engineer

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 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

i. *Dismantle the existing damaged asphalt joint sealant*

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

ii. *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).

iii. *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.

iv. *Rebar anchor*

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

v. *Pouring flexible asphalt 1st layer*

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

vi. *Installation of expansion sheet*

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

vii. *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

- i. Installation shall be carefully carried out so as not to cause unevenness, twisting, or other distortions.
- ii. The floor slab reinforcement at the joint device installation area shall be accurate and well connected to the anchors of the joint device.
- iii. 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 shall be taken to avoid localized bearing pressure conditions.
- iv. If the water stop material has joints, the connection method specified by the manufacturer in the installation manual shall 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 joints for bridges.

12803 DEFINITION

The behaviour of the bridges and their durability depend on the quality and maintenance of the expansion joints. It should be ensured that the expansion joints are watertight and 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 girders 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, Eurocode standards or equivalent ASTM Specification:

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

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 shall be determined based on manufacturer's instructions. The material test applied for tensile strength and elongation shall 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
5. Or any other equivalent material approved by the Engineer

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 carted away.

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 to cover 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. Substantial 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 the work of replacement of a bearing including 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 for the installed bearings be evaluated based on manufacturer's estimated service life and performance/ defect observations.

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

12903 DEFINITION

A bridge bearing is a component of a bridge which provides a resting surface between bridge substructures and the bridge girders.

12904 APPLICABLE STANDARDS

The bridge bearings shall be in accordance with the provisions of the relevant clauses of the BS 5400-9 or BS EN 1337-3.

EN 1993-1-1	Steel structure design
EN 1992	Concrete structure design

All the Eurocodes in 12905 in the material test applied for Hardness test shall be approved by the Engineer.

12905 MATERIALS

1. Bridge bearings
2. Rebar
3. Mortar/concrete
4. Or any other equivalent material approved by the Engineer

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 provisions 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 of installation shall depend on the manufacturer's specifications of the spatial means stipulated.

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 bridge 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 bearing seat mortar or the girders.

5. Dismantle jacks and temporary support for the final work

After replacement of the new bridge 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 shall be in number of bearings replaced.

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

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 bars, 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 of the material, order of works and application requirements for extension of the 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 Specification 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, 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 Eurocode 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 Specification for Road and Bridge Construction.

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
5. Or any other equivalent material approved by the Engineer

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 the 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: m³, Ton

Measurement shall be based on cubic metres (m³) 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:

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 jacking up 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 stiffeners, jacking up, jacking down, inspection of measurement, dismantling jacks and temporary supports. All jacking up 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 and re-arrangement of existing bearings.

The following shall be observed:

1. The amount of jacking up shall be adequate 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 shall be raised uniformly, and only one bearing shall 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 shall be a manual pump.

The jacks shall 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 shall be 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 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 bearing 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 shall 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 DEFINITION

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

The material shall be approved by the Engineer.

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 1 st coat
ASTM D7234, BS 3900	Anti-Corrosion Paint for 2 nd 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.
6. Or any other equivalent material approved by the Engineer

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

13206 ORDER OF WORKS

1. Surface preparation

i. *Preparation for paint removal*

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

ii. *Preliminary adjustment*

In the case of dust or salt adhesion of 50 mg/m² or more, the surface shall be thoroughly cleaned by washing with water immediately before painting in order to prevent delamination of the paint film.

iii. *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.

iv. *Inspecting the surface preparation and finish of the edges of the component*

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

The surface to be coated shall be cleaned to remove dust, sand, oil, grease and other harmful substances. If sea salt particles are adhering to the surface to be coated, the surface shall be 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

i. *Paint*

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

ii. *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 when doing the mix proportions to ensure consistency with the 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.

iii. *Application timelines after mixing*

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

3. Repainting

i. *Paint application*

- a. On-site painting shall be based on brush and airless spray application.
- b. 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.
- c. 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.

ii. *Conditions prohibiting painting work*

Refer to section 12200 of this section.

iii. *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) 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).

Necessary conditions of the surface before coating:

- a. 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.
- 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 defects on the coating film.

iv. *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.

v. *Work control*

Refer to section 12200 of this specification.

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: Repainting of steel bearing

Unit: m²

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 DEFINITION

The process under this section involves reinstatement of damaged slope protection around 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.

13305 MATERIALS

1. Stone masonry
2. Cobble stones
3. Sand bags
4. Gravel
5. Gabion mattress
6. Piles
7. Rock fill gabions
8. Concrete
9. Rebars
10. Filter Fabric Sheet (under gabion mattress)
11. Or any other equivalent material approved by the Engineer

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 in the drawings and/or as directed by the Engineer. 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

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 to approval of the Engineer.

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: m³

The 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 personnel, and work incidental for the excavation of scoured area.

Item: Placing concrete foundation

Unit: m³

The 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 personnel and work incidental for the placing concrete foundation.

Item: Filling and compaction of gravel

Unit: m³

The 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 personnel and work incidental for the filling and compaction of gravel.

Item: Placing masonry protection

Unit: m²

The 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 personnel and work incidental for the placing masonry protection.

Item: Installation of gabion mattress

Unit: m²

The work shall be paid based on a unit price per square meter for "Installation of gabion mattress", complete in place, which shall include all materials, containers, equipment, tools, labour, services of the technical personnel and work incidental for the installation of gabion mattress and backfill.

Item: Gabion mattress backfill

Unit: m³

The work shall be paid based on a unit price per cubic meter for "Gabion mattress backfill", complete in place, which shall include all materials, containers, equipment, tools, labour, services of the technical personnel 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 or equivalent Eurocode:

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	ASTM D4533-04(2009)

Permeability -10 cm head	BS EN ISO 12958:1999
Pore size	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/mm². 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/mm². 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.

6. Or any other equivalent material approved by the Engineer.

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

i. 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.

ii. 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 for 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 Specification 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
6. Or any other equivalent material approved by the Engineer

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. All the repair work shall be done in accordance with the drawings, specifications and Engineer's instructions.

13602 GENERAL

The nylon fibre 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 fibre 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 fibre gabion
2. Knitted fabric material
3. Rock Fill (Boulders)
4. Backfill Materials
5. Or any other equivalent material approved by the Engineer

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 fibre gabion shall weigh 2 tonnes with equivalent size of 3m x 2m and volume of about 1.24m³.

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 fibre 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: m³

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

This section covers scaffolding material required to elevated workers to a height that can facilitate ease of work and protect workers and tolls from falling.

13702 GENERAL

Scaffolding is necessary where a work at height of more than 1.8m is required.

13703 DEFINITION

Scaffolds are temporary structure that is made from metal poles and wood planks and erected to support construction workers, inspectors, cleaners and others who need to work at height.

There are various types of scaffolds.

The choice of scaffold to be used shall be determined by specific situational requirement and appropriate design and shop drawings for identified scaffolds, and as approved by the Engineer.

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

Metal scaffolds	BS 1139
Scaffold tube and coupler standards	EN 39
Scaffold performance requirement	EN 12811
Metal scaffolding	BS EN 1004
Metal flooring walkways & stair treads	BS 4592

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

Unit: m² for the given heights.

Payments are deemed to be included in the unit rates of the work items for heights less than 1.8m. For heights greater than 1.8m, scaffoldings shall be measured separately.

13800: REPAIR OF CRACKS BY STOP HOLE METHOD

13801 SCOPE OF SECTION

This section covers repair of cracks by stop hole method which involves drilling of existing steel plates, installation of a bolt and on-site painting. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

13802 GENERAL

The stop hole method is an emergency measure that prevents progression of fatigue cracks in steel structures. It involves drilling a small hole at the end of a crack or at a point where damage is detected. The purpose of this hole is to relieve the stress concentration at the tip of the crack, thereby preventing it from extending.

13803 DEFINITIONS

The stop hole repair method is a technique applied to prevent the propagation of cracks or further damage in steel components of a structure.

13804 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, ASTM Specification, British Standard, Eurocode or any other equivalent:

KS EN 1993 – 2	Design of Steel Structures
BS 5950	Design of Steel Structures
ASTM-A449	Strength of Bolts
BS EN ISO 15048	Structural Bolting Assembly
EN 1993	Design of Steel Structures

13805 MATERIALS

1. Bolts, washers and nuts
2. Epoxy zinc-rich primer
3. Thinner
4. Polyurethane aluminium paint (locally available)

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

13806 ORDER OF WORKS

1. Drilling of existing plates

The crack shall be examined and its end shall be identified; a hole shall then be drilled at the edge of the crack using a drill. Burrs shall be removed and the surface around the hole treated, finally a bolt with a nut and washers of suitable size shall be fixed and tightened.

2. On-site painting

Painting shall be done in accordance with section 12200 of this specification.

13807 MEASUREMENT AND PAYMENT

Item: Stop Hole Method

Unit: No.

The method of measurement for this repair method shall be by the number of stop holes drilled, 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.

**13900: REPAIR OF HEAT DAMAGE
ON STEEL BRIDGE**

13901 SCOPE OF SECTION

This section covers the repair of heat damage on steel bridge. It involves cleaning, surface preparation, removal of damaged material, welding and structural repairs, stress relief and annealing, surface finishing and protection, and quality inspection and testing.

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

13902 GENERAL

Repair of heat damaged steel sections is carried out to restore the structural strength, alignment and durability lost due to excessive temperatures that weaken or deform the metal. It is generally done by assessing the extent of damage and correcting distortion or defects through controlled straightening, welding or replacement.

13903 DEFINITIONS

Heat damage on a steel bridge refers to adverse changes in the properties and structural integrity of the steel components caused by exposure to high temperatures.

13904 APPLICABLE STANDARDS

The repair of heat damage shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, ASTM Specification, British Standard, Eurocode or any other equivalent:

KS EN 1993	Steel Structures Design
BS 3100	Steel Castings for General Engineering Purposes
ASTM-A757	Carbon and Alloy Steel Castings
BS ISO 20431:2023	Heat Treatment of Steel
BS EN 1993	Steel Structures Design

13905 MATERIALS

1. Steel section and accessories
2. Welding rods
3. Paint

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

13906 ORDER OF WORKS

1. Cleaning and surface preparation

The damaged sections of the steel bridge components shall be cleaned to remove any contaminants, debris and/or loose material in accordance to section 10200 of this specification.

3. Removal of damaged material

The severely damaged or weakened sections of steel members that cannot be repaired shall be removed by cutting them out as approved by the Engineer.

4. Welding and structural repairs

The deformed sections shall be heated under controlled temperatures and straightened, the severely damaged sections shall then be replaced with new steel sections or plates which shall be welded to the removed sections in accordance with the specifications and approved by the Engineer.

5. Stress relief and annealing

A heat treatment process shall be carried out to relieve internal stresses and improve the material's structural properties. This shall be determined and instructed by the Engineer.

6. Quality inspection and testing

Non-destructive testing (NDT) or other approved tests shall be conducted to ensure that the repairs meet the required quality and safety standards.

7. Surface finishing and protection

The repaired areas shall be finished to match the existing structure's surface finish and appropriate coatings, paints, or protective layers applied to prevent corrosion and enhance the steel's durability.

13907 MEASUREMENT AND PAYMENT

Item: Repair of Heat Damage on Steel Bridge

Unit: m²

Measurement shall be measured by the area of heat damage repaired on steel as approved by the Engineer.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for the repair of heat damaged steel element as detailed in plans and specifications.

14000: REPAIR OF SPLITTING TIMBER SECTIONS BY SPLIT BANDING

14001 SCOPE OF SECTION

This section covers the repair of splitting timber sections by split banding which involves installation and tightening of steel bands around a timber member to prevent further cracks, splits or delamination. All repair works shall be performed in accordance with the drawings, specifications and Engineer's instructions.

14002 GENERAL

To repair the cracked wooden bridge members and restore structural durability and safety, the location of the crack and the extent of the damage shall be assessed first and subsequently clamped then reinforced around the clamp.

14003 DEFINITIONS

Split banding is a repair technique applied to reinforce a damaged timber section using metal straps.

14004 APPLICABLE STANDARDS

The section be in accordance with the provisions of the relevant clauses of the Kenyan Standards, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
BS 5268	Structural Use of Timber
BS EN 1995	Design of Timber Structures

14005 MATERIALS

1. Steel band
2. Bolts and nuts

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

14006 ORDER OF WORKS

1. Cleaning

Loose material shall be removed from the split timber as specified in section 10200 of this Specification.

2. Clamping

The split timber section shall be clamped as approved by the Engineer.

3. Installation and tightening of the steel bands

The steel band shall be positioned and tensioned using a strapping machine or approved device. Bolts and nuts shall then be fastened on both ends of the steel band using a wrench to the recommended tension by the Engineer.

14007 MEASUREMENT AND PAYMENT

Item: Repair of Splitting Timber Sections by Split Banding

Unit: No.

The method of measurement for this repair method shall be by number of steel bands installed, 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.

14100: REPAIR OF SPLIT TIMBER BY ANTI-SPLIT BOLT

14101 SCOPE OF SECTION

This section covers repair of split timber by anti-split bolt which involves drilling through split timber members and installing anti-split bolts. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

14102 GENERAL

This method involves inserting bolts (in conjunction with other repair techniques which include epoxy resins to create a robust and lasting repairs) through the timber to hold the split sections together. It is particularly effective for severe splits that cannot be easily repaired by other means.

14103 DEFINITIONS

An anti-split bolt is a metal fastener used to repair and reinforce timber that has split. It is inserted through the timber to hold the split sections together, providing additional support and preventing further splitting.

14104 APPLICABLE STANDARDS

The anti-split bolt shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, ASTM Specification, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
EN 1993	Design of Steel Structures
BS 5950	Design of Steel Structures
EN 17418:2021	Two Component Epoxy and Polyurethane Adhesives for Onsite Repair of Cracked Timber Structures

14105 MATERIALS

1. Bolts and nuts
2. Splints
3. Epoxy resins or equivalent

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

14106 ORDER OF WORKS

1. Cleaning

Loose material shall be removed from the split timber as specified in section 10200 of this Specification.

2. Drilling of timber

A hole shall be drilled as detailed in the design drawings and as instructed by the Engineer.

3. Application of epoxy resin

Epoxy resin or equivalent material shall be applied to the drilled holes as directed by the Engineer.

4. Installation and securing with bolts

Splints shall be installed and secured with bolts and fastened to the recommended tension.

14107 MEASUREMENT AND PAYMENT

Item: Anti-Split Bolt

Unit: No.

The method of measurement for this repair method shall be by the number of anti-split bolts installed, 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.

14200: REPAIRING SPLITTING TIMBER STRINGER BY REPLACEMENT

14201 SCOPE OF SECTION

This section covers repairing splitting timber stringer by replacement. It involves removal and replacement of kerbs, decking and stringers. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

14202 GENERAL

Repair of a splitting timber stringer through replacement method involves the systematic removal of the existing kerbs, decking and deteriorated stringer and safe installation of a new structurally compliant member.

14203 DEFINITIONS

A stringer is a structural element in a bridge, typically a long horizontal beam that supports the decking and transfers loads to the piers or abutments.

14204 APPLICABLE STANDARDS

The replacement of timber stringer shall be in accordance with the provisions of the Kenyan Standards, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
BS 5268	Structural Use of Timber
BS EN 1995	Design of Timber Structures
EN 1993	Design of Steel Structures (For the steel fastening elements)

14205 MATERIALS

1. Timber stringers
2. Galvanized threaded rods or lag bolts
3. Steel channels, plates, or angles

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

14206 ORDER OF WORKS

1. Removal of kerbs

The process begins with the removal of the kerbs, which are the raised edges along the sides of the bridge. These kerbs are set aside for reuse.

2. Removal of decking

The deck shall be removed and preserved for reuse.

3. Removal of damaged stringers

The adjacent stringers and decking shall be supported using temporary props or jacks to prevent structural instability. Subsequently, the bolts, straps or steel connections securing the damaged stringer shall be removed before removal of the damaged stringer using appropriate handling equipment. The bearing seats, beams, abutments shall be inspected for any secondary damage and report findings to the Engineer.

4. Fabrication of new stringers

The new stringers shall be cut to match the design requirements. Holes for bolts and connectors shall be drilled to prevent splitting and apply preservative treatment to all faces.

5. Installation of new stringers

The new stringers shall be positioned on to the designated bearing points as per the drawings and proper seating, alignment, level and spacing verified, relative to the adjacent stringers. All bolts, steel channels, plates or angles shall then be installed as specified while ensuring full and uniform bearing at supports as directed by the Engineer.

14. Reinstallation of decking

Once the new stringers are in place, the previously removed decking shall be reinstalled. This shall involve laying down the preserved wooden planks to form the bridge floor, providing a stable and durable surface for traffic.

15. Reinstallation of kerbs

The previously removed kerbs shall be fitted back along the edges of the bridge. This shall complete the repair process, restoring the bridge to its original condition and ensuring its structural integrity.

14207 MEASUREMENT AND PAYMENT

Item: Replacement of Timber Stringer

Unit: m

The method of measurement for this repair method shall be by the length of stringer installed, 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.

14300: REPAIRING SPLITTING TIMBER STRINGER BY RELIEVING

14301 SCOPE OF SECTION

This section covers repairing splitting timber stringer by relieving which involves placement of hydraulic jacks on the crosshead, jacking up, bolting timber stringers or universal steel beams (UB) to the crosshead, and jacking down. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

14302 GENERAL

Relieving a splitting timber stringer involves several key steps to ensure the structural integrity of the bridge is restored. The hydraulic jack is placed on the crosshead and jacked up to lift the affected area; this relieves the load on the splitting stringer. Timber stringers or universal steel beams (UB) are bolted to the crosshead to provide additional support then the hydraulic jack is carefully jacked down, transferring the load to the newly installed supports and ensuring the stability of the structure.

14303 DEFINITIONS

Repairing splitting timber stringer by relieving is a technique used to reinforce a defective timber with additional member to restore its structural integrity.

14304 APPLICABLE STANDARDS

The universal beams shall be in accordance with the provisions of the Kenyan Standard, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
BS 5950	Design of Steel Structures
BS EN 1993	Design of Steel Structures

14305 MATERIALS

1. Timber stringer/ Universal steel beams (UB)
2. Bolts and nuts
3. Steel plates or angle lines

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

14306 ORDER OF WORKS

1. Jacking up

The process shall be done in accordance with section 13100 of this specification by placing a hydraulic jack on the crosshead and jacking it up. This shall lift the affected area, relieving the load on the splitting timber stringer.

2. Installation of timber stringers or UB

Once the area is lifted, timber stringers or universal steel beams (UB) matching the original design specifications or superior shall be connected to the crosshead as directed by the Engineer.

3. Jacking down

The hydraulic jack shall be jacked down in accordance with section 13100 of this specification.

14307 MEASUREMENT AND PAYMENT

Item: Repairing Splitting Timber Stringer by Relieving

Unit: m

The method of measurement for this repair method shall be by the length of stringer installed, 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.

14400: REPLACEMENT OF SPLIT CORBELS

14401 SCOPE OF SECTION

This section covers replacement of corbels which involves removal and replacement of kerbs, decking, stringers and corbels. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

14402 GENERAL

Replacement of a timber corbel is done to restore support and stability when the existing corbel has deteriorated, decayed or lost its load bearing capacity. The process generally involves removing the defective timber, preparing the bearing area and installing a new corbel.

14403 DEFINITIONS

A corbel in a timber bridge is a short structural beam that projects from a wall or column to support loads, distributing the weight of the structure the supporting elements.

14404 APPLICABLE STANDARDS

The timber corbel and lag bolts shall be in accordance with the provisions of the Kenyan Standards, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
BS 5950	Steel Structure
ASTM D4761	Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material.
BS 5268	Structural Use of Timber
BS EN 1993	Design of Steel Structures

14405 MATERIALS

1. Timber
2. Bolts and nuts
3. Steel plate or angle lines

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

14406 ORDER OF WORKS

1. Removal of kerbs

The kerbs shall be removed and set aside for reuse.

2. Removal of decking

The decking shall be removed to allow access of the stringers beneath.

3. Removal of stringers

The stringers shall be removed and set aside for reuse.

4. Removal of split corbels

The damaged corbel shall be removed after the adjacent corbels are supported using temporary props or jacks to prevent structural instability

5. Installation of new corbels

The new corbel shall be positioned on to the designated bearing points as per the drawings. The seating, alignment, level and spacing relative to the adjacent corbels shall be verified before installation of all bolts, steel channels, plates or angles as specified by the Engineer.

6. Reinstallation of stringers

Once the new corbels are in place, the stringers shall be reinstalled to their original positions.

7. Reinstallation of decking

Once the stringers are in place, the removed decking shall be reinstalled by laying down the preserved wooden planks to form the bridge surface.

8. Reinstallation of kerbs

The previously removed kerbs shall be fitted back along the edges of the bridge to complete the repair process, restoring the bridge to its original condition and ensuring its structural integrity.

14407 MEASUREMENT AND PAYMENT

Item: Replacement of Split Corbel

Unit: No.

The method of measurement for this repair method shall be by the number of corbels repaired, 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.

14500: REPLACING SPLIT SPIKING PLANKS

14501 SCOPE OF SECTION

This section covers replacing split spiking planks which involves removal and replacement of kerbs, decking and spiking planks. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

14502 GENERAL

The replacement of split spiking planks is done to restore the structural integrity of bridge decking. The process involves removal of all the defective planks and replacing with new ones.

14503 DEFINITIONS

A spiking plank in a timber bridge refers to wooden planks installed edgewise and spiked together to form a laminated deck panel.

14504 APPLICABLE STANDARDS

The spiking planks shall be in accordance with the provisions of the Kenyan Standard, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
BS 5268	Structural Use of Timber
ASTM D4761	Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material.
BS EN 1995	Design of Timber Structures

14505 MATERIALS

1. Timber
2. Nails

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

14506 ORDER OF WORKS

1. Removal of kerbs

The kerbs shall be removed and set aside for reuse.

2. Removal of decking

The existing wooden decking shall be removed and preserved for reuse.

3. Removal & replacement of spiking planks

The split spiking planks shall be removed and replaced with new ones.

4. Reinstallation of decking

Once the new spiking planks are in place, the decking shall be reinstalled by laying down the preserved wooden planks to form the bridge floor, providing a surface for traffic.

5. Reinstallation of kerbs

The removed kerbs shall be fitted back along the edges of the bridge to complete the repair process, restoring the bridge to its original condition and ensuring its structural integrity.

14507 MEASUREMENT AND PAYMENT

Item: Spiking Plank

Unit: m

The method of measurement for this repair method shall be by length of spiking plank replaced, 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.

14600: REPLACING TIMBER CROSSHEAD

14601 SCOPE OF SECTION

This section covers replacement of timber crossheads (cap wales/ half caps) which involves removal and reinstallation of kerbs, decking, stringers and corbels. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

14602 GENERAL

Replacing timber crosshead involves removing and replacing these key structural components of a bridge. In the process other elements such as kerbs, decking, stringers and corbels are removed and reinstalled.

14603 DEFINITIONS

The timber crosshead are structural components used in bridge construction. They provide support and stability to the bridge by distributing loads and connecting various elements such as stringers and corbels.

14604 APPLICABLE STANDARDS

The half cap shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
BS 5268	Structural Use of Timber
ASTM D4761	Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material.
BS EN 1995	Design of Timber Structures
BS 5950	Design of Steel Structures

14605 MATERIALS

1. New cross head planks
2. Bolts/lock nuts and washers
3. Grease
4. Bituminous felt
5. Water proofing agent
6. Nails

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

14606 ORDER OF WORKS

1. Removal of kerbs

The kerbs shall be removed and set aside for reuse.

2. Removal of decking

The deck shall then be removed to allow access to the stringers and other supporting elements beneath and preserved for reuse.

3. Removal of stringers

The stringers shall be removed to expose the corbels and the timber crosshead for ease of their removal and preserved for reuse.

4. Removal of corbels

After removal of the stringers, the corbels shall then be removed to facilitate the removal and replacement of the timber crosshead. They shall be preserved for reuse.

5. Removal and replacement of the timber crosshead

The existing timber crosshead shall be removed and replaced with new ones. It shall be ensured that the components are installed, aligned and fastened as instructed by the Engineer.

6. Reinstallation of corbels

The corbels shall be reinstalled in place to provide adequate support for the stringers and decking.

7. Reinstallation of stringers

The stringers shall be reinstalled in accordance with the Engineer's instructions to ensure they are properly aligned and fastened to the corbels and other supporting structures.

8. Reinstallation of decking

The deck shall be reinstalled as directed by the Engineer to ensure proper alignment for a stable riding surface.

9. Reinstallation of kerbs

The kerbs shall then be reinstalled to complete the replacement process.

14607 MEASUREMENT AND PAYMENT

Item: Replacing Timber Crossheads

Unit: No.

The method of measurement for this repair method shall be by the number of timber crossheads replaced, 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.

14700: REPAIRING TIMBER DECK

14701 SCOPE OF SECTION

This section covers repairing timber deck which involves removal and reinstallation of ancillary members and replacing the defective decking with a new one. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

14702 GENERAL

The replacement of split spiking planks is done to restore the structural integrity of bridge decking. The process involves removal of all the ancillary members, defective planks and replacing with new ones.

14703 DEFINITIONS

Decking in a timber bridge refers to the wooden surface that forms the bridge surface. It supports the loads from traffic and distributes these loads to the underlying stringers. Typically made of solid sawn lumber or laminated timber, the decking provides a stable and durable surface for vehicles and pedestrians to cross.

14704 APPLICABLE STANDARDS

The timber deck and bolts shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
KS EN 1995 – 2	Design of Timber Structures
BS 5268	Structural Use of Timber
ASTM D4761	Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material.
BS EN 1995 – 2	Design of Timber Structures
BS 5950	Design of Steel Structures

14705 MATERIALS

1. New deck planks
2. Bolts/lock nuts and washers/Nails

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

14706 ORDER OF WORKS

1. Cleaning

Loose material shall be removed from the decking as specified in section 10200 of this Specification.

2. Removal of ancillary members

All ancillary bridge members shall be removed and set aside for reuse.

3. Removal of defective decking

The defective planks shall be cut or removed to reach sound materials while avoiding damage to adjacent sections. Any exposed timber surfaces shall then be treated to prevent future deterioration.

The underlying structures shall be inspected for any damages. If defects are found their nature and extent shall be assessed and any required repairs or corrective work shall be carried out as directed by the Engineer before installing new decking.

4. Installation of decking planks

Replacement timber shall be cut and shaped to fit precisely within the removed area ensuring that all new planks match the specifications of the existing deck and comply with the Engineer's instructions. The new timber sections shall be connected to the adjacent deck members or supports ensuring proper alignment, continuity and load transfer to the rest of the deck. The new sections shall also be treated as approved by the Engineer.

5. Reinstallation of ancillary members

The ancillary bridge members shall be reinstalled to ensure all components are correctly positioned, secured and restored to full functionality.

14707 MEASUREMENT AND PAYMENT

Item: Repairing Timber Deck

Unit: m²

The method of measurement for this repair method shall be by the area of the repaired deck, 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.

14800: REPAIRING TIMBER KERBS

14801 SCOPE OF SECTION

This section covers removal and replacement of kerbs.

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

14802 GENERAL

The repair of timber kerbs involves the removal of the existing kerbs and installation of the new timber kerbs.

14803 DEFINITIONS

A kerb is a longitudinal member at the edge of a deck used to support barriers and provide edges restraint to vehicles.

14804 APPLICABLE STANDARDS

The timber kerbs and bolts shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
KS EN 1995 – 2	Design of Timber Structures
BS 5268	Structural Use of Timber
ASTM D4761	Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material.
BS EN 1995	Design of Timber Structures
BS 5950	Design of Steel Structures

14805 MATERIALS

1. Timber kerbs
2. Lag bolts or threaded rods
3. Galvanized M20 replacement bolts
4. Chemical timber surface preservatives
5. Waterproofing agents
6. CN Emulsion/Timber oil or thick preservative grease
7. Bituminous felt
8. Paint

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

14806 ORDER OF WORKS

1. Cleaning

Loose material shall be removed from the decking as specified in section 10200 of this Specification.

2. Removal of damaged kerbs

All the bolts, straps and connections securing the existing kerbs shall be removed. Carefully detach the kerb to avoid causing damage to the deck or drainage components.

3. Installation of new kerbs

Position the kerb in its original or specified alignment, provide bituminous felt or approved interface material to prevent moisture damage as directed by the Engineer. Fix the kerb using approved bolts or threaded rods, apply surface preservatives, waterproofing agents or timber oils as specified. Finish with approved paint or protective coating.

14807 MEASUREMENT AND PAYMENT

Item: Repairing Timber Kerb

Unit: m

The method of measurement for this repair method shall be by the length of repaired kerb, 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.

14900: INSTALLATION OF FLASHING

14901 SCOPE OF SECTION

This section covers cleaning and installation of new flashing.

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

14902 GENERAL

Flashing is a vital component in the construction of timber bridges, designed to prevent water infiltration and moisture-related damage to the structure. Proper installation of flashing is essential to ensure bridge's durability and longevity.

A comprehensive assessment of the bridge shall be conducted to identify areas vulnerable to water infiltration, such as joints, intersections, and areas close to the ground. A detailed plan shall be developed, specifying the type of flashing material, placement locations, dimensions, and installation techniques.

14903 DEFINITIONS

Flashing in a timber bridge refers to a protective layer or material installed to prevent water infiltration and moisture-related damage to the structure. A protective layer is typically classified as either preformed sheet membrane or liquid applied membranes.

14904 APPLICABLE STANDARDS

The waterproofing membrane shall be in accordance with the provisions of the Kenyan Standard, British Standard, Eurocode or any other equivalent:

KS 828-1:2009	Structural Use of Timber – Part I Permissible Stress Design, Materials and Workmanship – Code of Practice
BS 8102	Protection of Below Ground Structures Against Water Ingress
BS 5268	Structural Use of Timber
ASTM D4761	Standard Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material.
BS EN 1995	Design of Timber Structures

14905 MATERIALS

1. Liquid applied membrane/ preformed sheet membrane (Aluminium, copper, galvanized steel)
2. Self-tapping screws/ nails (If required)

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

14906 ORDER OF WORKS

1. Cleaning

The timber surfaces shall be cleaned in accordance with the Engineer's instructions to ensure the surface is clean, dry and free of loose material.

2. Selection and installation of flashing material

Appropriate flashing material shall be chosen based on the bridge design, location and environmental conditions. Common options shall include preformed sheet membranes (e.g., aluminium, copper, galvanized steel) or liquid applied membranes (epoxy resins and polyurethane).

i. *Preformed sheet membranes*

a. *Cut and shape the flashing*

The flashing material shall be cut into the required lengths and shapes based on the dimensions and layout of the bridge components.

b. *Installation of base flashing*

A base flashing shall be installed at the base of vertical timber components to create a watertight seal.

The base flashing shall be attached using appropriate fasteners, ensuring a stable and secure connection as directed by the Engineer.

c. *Installation of step flashing*

A step flashing shall be installed at junctions between the horizontal and vertical timber components to channel water away from the vulnerable areas.

The step flashing shall be secured using fasteners as directed by the Engineer.

d. *Overlap and securing of the flashing*

It shall be ensured that the flashing pieces overlap each other to create a continuous barrier against water infiltration.

The flashing shall be secured in place using appropriate fasteners, ensuring a tight seal and preventing water penetration. This shall be done as directed by the Engineer.

ii. *Liquid applied membranes*

a. *Sealing of joints and seams*

Compatible sealants or waterproofing materials shall be applied to all joints, seams, and fastener penetrations to further enhance water resistance.

It shall be ensured that the sealants are applied evenly to cover all potential points of water entry.

b. Curing

Allow for curing as specified by the manufacturer and directed by the Engineer.

c. Application of the second coat

Apply second coat in a perpendicular manner to the first coat.

3. Inspection and testing

Detailed inspections shall be conducted to verify the integrity of the flashing installation, ensuring proper alignment, secure attachment, and effective sealing.

Water tests shall be performed to validate that the flashing system effectively redirects water away from the vulnerable areas.

Continuous adhesion flashing shall be checked to ensure there are no air pockets.

4. Completion of installation

Once the flashing is in place and tested for water tightness, any remaining construction or finishing work on the bridge shall be completed to the Engineer's satisfaction.

14907 MEASUREMENT AND PAYMENT

Item: Installation of Flashing

Unit: No.

The method of measurement for this repair method shall be by the number of flashings installed, 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.

15000: REPLACING AND REPOINTING STONework

15001 SCOPE OF SECTION

This section covers removal of defective masonry stones, cleaning surface of masonry, mixing of mortar, replacement of masonry stones and mortar placing and curing.

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

15002 GENERAL

This involves the restoration of old mortar and/or bricks that have lost their structural integrity. Over time, the mortar between masonry stones deteriorates due to weathering, water wash, and moisture penetration from the fill behind the walls. When the depth of mortar loss reaches 20mm, repointing of the stonework is required. If the depth of mortar loss exceeds 20mm, stone movement or crushing of the remaining mortar can occur, leading to slippage of stones in arches or dislodgement of stones in walls.

In cases where aesthetics is not a concern, blocks can be replaced with concrete or a stiff mortar mix. Care must be taken to ensure that concrete does not slump or shrink away from the surrounding stones.

15003 DEFINITIONS

Repointing is the process of removing deteriorated or loose mortar from the joints between the stones and replacing with fresh mortar.

15004 APPLICABLE STANDARDS

The materials shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete

15005 MATERIALS

1. Cement
2. Fine aggregate (sand)
3. Masonry stone
4. Water

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

15006 ORDER OF WORKS

1. Removal of defective masonry stones

The defective masonry stones shall be removed. During this process, it shall be ensured that the old mortar is also removed to create a clean surface for the fresh mortar.

2. Cleaning of masonry surface

The surface of the remaining masonry stones shall be cleaned to eliminate any debris, dust or loose particles to ensure proper adhesion with the fresh mortar.

3. Mixing of mortar

The mortar shall be prepared by mixing sand, water, and cement in the appropriate proportions as instructed by the Engineer.

4. Replacement of masonry stones

The defective masonry stones shall be replaced with new ones, ensuring that they are properly aligned with the mixed mortar evenly applied to bond the new stones to the existing structure in accordance to the Engineer's instructions.

5. Curing

The mortar shall be cured as approved by the Engineer.

15007 MEASUREMENT AND PAYMENT

Item: Replacing and Repointing Stonework

Unit: m²

The method of measurement for this repair method shall be by the area of stonework repaired, 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.

**15100: REPAIR OF SPLIT/
CRACKED BLOCKS OR MORTAR**

15101 SCOPE OF SECTION

This section covers repair of split/ cracked blocks or mortar involving the removal of defective portions, cleaning surface, mixing, placing and curing of mortar.

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

15102 GENERAL

The repair of split/ cracked blocks or mortar involves removal of the defective portions, application of new mortar and curing as instructed by the Engineer.

15103 DEFINITIONS

Mortar is a mixture of sand, water, and cement used in building to bond bricks or stones together. It acts as a binding agent, ensuring the stability and integrity of masonry structures.

15104 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and Specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete

15105 MATERIALS

1. Cement
2. Fine aggregate (sand)
3. Water

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

15106 ORDER OF WORKS

1. Removal of defective portions

The defective portions of the blocks or mortar shall be removed to ensure that all the damaged material is eliminated to provide a clean and stable base for the repair.

2. Cleaning the surface

The surface of the remaining blocks and surrounding area shall be cleaned to remove any debris, dust, or loose particles to ensure proper adhesion of the fresh mortar.

3. Mixing of mortar

Mortar shall consist of one part by weight of cement to three parts by weight of sand. The materials shall be accurately gauged and mixed in an approved manner. Cement mortar shall be made in suitable small quantities only and when required, and any mortar which has begun to set or which has been mixed for a period of more than the initial setting time shall be rejected.

4. Mortar placing

The mixed mortar shall be applied evenly to fill all the cracks to provide a strong and stable repair.

5. Curing

The mortar shall be cured as approved by the Engineer.

15107 MEASUREMENT AND PAYMENT

Item: Repair of Split/ Cracked Blocks or Mortar

Unit: No.

The method of measurement for this repair method shall be by number of repaired cracked blocks, 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.

**15200: REPAIR OF BULGING
SIDEWALL (SPANDREL WALL)**

15201 SCOPE OF SECTION

This section covers the repair of bulging sidewall involving the removal of defective portion, mortar mixing work, mortar placing and curing.

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

15202 GENERAL

The repair of a bulging sidewall (spandrel wall) involves removal of defective portions, application of new mortar and curing as instructed by the Engineer.

15203 DEFINITIONS

Mortar is a mixture of sand, water, and cement or lime used in building to bond bricks or stones together. It acts as a binding agent, ensuring the stability and integrity of masonry structures.

15204 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete

15205 MATERIALS

1. Cement
2. Fine aggregates (Sand)
3. Water
4. Epoxy
5. Galvanized tie rods
6. Plastic sheath
7. Metal cover plates
8. Masonry stone

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

15206 ORDER OF WORKS

1. Demarcate bulged sections on side wall (spandrel wall)

Demarcation of bulged sections on the side wall (spandrel wall) shall be carried out accurately and carefully.

2. Removal of defective portion

The defective portions of the sidewall shall be removed to provide a clean and stable base for repair.

3. Cleaning the surface

The surface of the remaining sidewall (spandrel wall) shall be cleaned to eliminate any debris, dust or loose particles to ensure proper adhesion of the new mortar.

4. Mortar mixing work

Mortar shall consist of one part by weight of cement to three parts by weight of sand. The materials shall be accurately gauged and mixed in an approved manner. Cement mortar shall be made in suitable small quantities only and when required, and any mortar which has begun to set or which has been mixed for a period of more than the initial setting time shall be rejected.

5. Masonry block placing

Masonry blocks shall be cleaned prior to use to remove any adhered debris, mud, or other contaminants, and placing shall be carried out in accordance with the design documents and the Engineer's instructions.

6. Mortar placing

The mixed mortar shall be applied to the cleaned surface, filling the gaps and cracks. It shall be ensured that the mortar is placed evenly and fills all joints to provide a strong and stable repair.

7. Installation of tie rods across the side wall

In accordance with the design documents and the Engineer's instructions, holes shall be drilled using a concrete drilling machine, a plastic sheath shall be placed, a tie rod inserted into the sheath, and the opening sealed with a metal cover plate.

8. Waterproofing and drainage

Following tie rod installation, drainage pipes shall be installed on the repaired sidewall (spandrel wall) in accordance with the design documents and the Engineer's instructions.

9. Repointing masonry using mortar

The existing mortar packed in the joints between existing masonry blocks or bricks shall be removed, and the joints shall be repointed with fresh mortar.

10. Curing

The mortar shall be cured as approved by the Engineer.

15207 MEASUREMENT AND PAYMENT

Item: Repair of Bulging Sidewall (Spandrel Wall)

Unit: m²

The method of measurement for this repair method shall be by the area of repaired bulging sidewall, 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.

15300: STABILISING ABUTMENT OR WING WALL MOVEMENT

15301 SCOPE OF SECTION

This section covers stabilising abutment or wing wall movement involving excavation for the anchor block (dead man), concrete plate/abutment wall drilling, slurry injection and filling in drilling holes.

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

15302 GENERAL

The process of stabilising abutment or wing wall movement involves excavation, drilling or coring holes through the walls and embankment, inserting tensioning rods, and fixing them into anchor block cast in an excavated hole behind the wall. After installing the pre-tensioning tie rods, the excavation is backfilled with compacted fill, and slurry is injected into the drilled holes to fill any voids. The drilling holes are then filled with appropriate materials to secure the tensioning rods, and the cracks in the walls are epoxy grouted to restore structural integrity.

15303 DEFINITIONS

Slurry is a semi-liquid mixture, typically consisting of fine particles of materials such as cement suspended in water. It is commonly used in construction and industrial processes to transport solids or fill voids.

15304 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standard, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete
BS EN 12274	Slurry surfacing test methods

15305 MATERIALS

1. Cement
2. Aggregates (Fine and coarse)
3. Water
4. Tensioning rods
5. Epoxy

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

15306 ORDER OF WORKS

1. Excavation for anchor block

The embankment shall be excavated in a controlled manner to the required depth as instructed by the Engineer.

2. Concrete plate drilling

Holes shall be drilled through the walls and embankment as instructed by the Engineer.

3. Installation of the tensioning rods

The tensioning rods shall be inserted into the holes and pushed through the embankment. The rods shall be galvanized and sheathed in plastic over the length they are within the embankment fill.

The tensioning rods shall be installed by fixing them into the anchor block cast into an excavated hole.

4. Backfilling

After installation of the pre-tensioning tie rods, the excavation shall be backfilled using approved material. Backfill shall be placed in layers and compacted to the densities specified by the Engineer.

5. Slurry injection

After backfilling the slurry shall be injected into the drilled holes to fill any voids and ensure stability.

6. Filling in drilled holes

The drilled holes shall be filled with appropriate materials to secure the tensioning rods and prevent further movement.

The cracks on the walls shall be repaired in accordance with Section 10900 of this Specification.

15307 MEASUREMENT AND PAYMENT

Item: Stabilising Abutment or Wing Wall Movement

Unit: No.

The method of measurement for this repair method shall be by number of wingwalls repaired, 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.

**15400: ARCH CRACKING OR
SPALLED REPAIR**

15401 SCOPE OF SECTION

This section covers repair of cracks and spalling in arches. It involves cleaning and repairing of defective areas and applying appropriate repair materials.

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

15402 GENERAL

The process for repairing cracks or spalled areas in arch bridges involves removing of defective material and replacing with suitable material.

15403 DEFINITIONS

Arch cracking in masonry bridges refers to the development of fissures within the arch structure of a masonry bridge. The arch cracks may occur as a result of settlement and movement, thermal expansion and contraction, material deterioration, loading and overloading, seismic activity, design or construction flaws.

15404 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, ASTM Specification or equivalent Eurocode:

KS EN 1996 – 2: 2006	Design of Masonry Structures
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 D 7234, BS EN 1504-5	Bond Strength to Concrete (Dry/Wet)

15405 MATERIALS

1. Masonry material (Quarry stone/block/brick)
2. Mortar
3. Bonding agent
4. Epoxy/ Grout

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

15406 ORDER OF WORKS

1. Cleaning and surface preparation

The cracks or spalled areas shall be cleaned to remove any loose debris, dirt, or contaminants that could affect the adhesion of the repair materials.

2. Repairing of defective sections

a. Cracks

i. Drilling of holes and fixing of injection pipes

Holes shall be drilled along the length of the cracks and injection pipes fixed into the holes. This shall facilitate the injection of the epoxy grout into the cracks.

ii. Application of the repair material

The appropriate repair material such as epoxy, grout or mortar shall be injected into the cracks through the injection pipes, ensuring that the material penetrates and fills the crack.

b. Spalling

i. Preparation of surface

After cleaning the surface, a bonding agent shall be applied to the surface to enhance adhesion.

ii. Application of the repair material

The spalled area shall be filled with the appropriate repair material such as mortar or concrete as instructed by the Engineer.

3. Curing

The repaired surface shall be cured in accordance with the manufacturer's specifications. This shall ensure that the repair material achieves the necessary strength and durability.

15407 MEASUREMENT AND PAYMENT

Item: Arch Cracking

Unit: m

The method of measurement for this repair method shall be by the length of repaired crack, 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.

15500: MASS CONCRETE UNDERPINNING

15501 SCOPE OF SECTION

This section covers mass concrete underpinning which involve excavation of pit, concrete mix work, construction of temporary concrete foundation, horizontal boring into pier, installation of steel section, removal of temporary concrete foundation, and backfilling with soil. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

15502 GENERAL

The process involves increasing the size of the present foundation to Specifications. Pegs are used to reveal the soil beneath the current foundation. After the desired layers have been reached, the excavation is filled with concrete and backfilled with suitable material.

15503 DEFINITIONS

Mass concrete underpinning involves excavating pits below the existing foundation and pouring mass concrete into the excavated pits to provide additional support and stability hence strengthening and stabilizing the existing structure.

15504 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete
BS EN 1992	Design of reinforced concrete structures
BS 8004	Code of practice for foundations
BS 8476:2007	Safe use of concrete pumps
BS EN 12001:2012	Conveying, spraying and placing machines for concrete and mortar. Safety requirements
BS 8110	Structural design of reinforced and prestressed concrete

15505 MATERIALS

1. Steel section
2. Formwork
3. Grout
4. Cement
5. Aggregates (Fine and Coarse)

6. Water

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

15506 ORDER OF WORKS

1. Excavation of pit

A detailed survey shall be conducted to mark the specific locations for the pits. Pits shall be excavated below the existing foundation at the marked locations, ensuring the depth and dimensions are appropriate based on structural load and soil conditions.

2. Construction of temporary foundation of concrete

Temporary support structures (steel sections) shall be installed to ensure the stability of the existing structure during the excavation process. A layer of blinding concrete or a suitable levelling material shall be placed at the base of the excavated pits as instructed by the Engineer.

3. Horizontal boring into pier

Horizontal boring shall be conducted in the pier as required by the design specifications.

4. Installation of steel sections

Steel sections shall be installed to provide additional support and stability to the structure.

5. Excavation of additional pits

Additional pits shall be excavated as necessary, ensuring they are properly cleaned and prepared for concrete placement.

6. Concrete mix work

The concrete mix C30/35 shall be prepared as directed by the Engineer for the next phase of the underpinning process.

7. Concrete placing

The concrete shall be placed into the excavated pits, ensuring it completely fills the pits and forms a solid foundation. Concrete shall be evenly distributed and compacted to eliminate air pockets. Curing shall be done as approved by the Engineer.

8. Removal of temporary foundation

After curing, the temporary support structures shall be removed and the horizontal boring on pier grouted as directed by the Engineer.

9. Backfilling

Backfilling shall be done with suitable material as directed by the Engineer.

15507 MEASUREMENT AND PAYMENT

Item: Concrete

Unit: m³

The method of measurement for this repair method shall be by the volume of concrete, 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.

15600: PILE UNDERPINNING

15601 SCOPE OF SECTION

This section covers the works involved in pile underpinning for bridge repair, including horizontal boring in a pier, insertion of needle beams and bearing plates, temporary supports using rigid rack and jack, manual excavation of pits, timbering, installation of formworks, placement of reinforcing bars, concrete production and placement, and backfilling.

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

15602 GENERAL

Pile underpinning shall be undertaken to stabilise or strengthen an existing pier or foundation where inadequate bearing capacity, settlement, deterioration or structural distress has been identified.

15603 DEFINITIONS

Pile underpinning is a technique involving installation of piles or reinforced concrete elements beneath an existing structure to strengthen or stabilize the foundation of a structure, when the existing foundation is inadequate or unstable.

15604 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete
BS EN 1992	Design of reinforced concrete structures
BS 8004	Code of practice for foundations

15605 MATERIALS

1. Anchors or Tendons
2. Formwork
3. Cementitious mortar or Adhesive
4. Cement
5. Aggregates (Fine and Coarse)
6. Water
7. Reinforcement bars
8. Steel sections (piles)

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

15606 ORDER OF WORKS

1. Horizontal boring in a pier

Horizontal boring shall be conducted in the pier as required by the design specifications and as instructed by the Engineer. This shall involve drilling horizontally into the pier to create a space for the insertion of support elements. The bore shall be cleaned prior to insertion of support elements.

2. Insertion of a needle beam and bearing plates

A steel or reinforced concrete needle beam and bearing plates shall be inserted into the bored holes. The needle beam shall provide horizontal support, while the bearing plates shall distribute the load evenly. All components shall be aligned and seated properly to avoid eccentric loading.

3. Support using rigid rack and jack system

The structure shall be temporarily supported using a rigid rack and jack system to ensure the stability of the existing structure during the underpinning process.

The system shall be monitored during jacking to prevent overstressing and approved by the Engineer prior to its use.

4. Manual excavation of pits

Pits shall be manually excavated at the marked locations to the specified depth. This shall involve careful digging to avoid disturbing the existing foundation. The excavated material shall be stockpiled separately for reuse where approved.

5. Timbering

Timbering shall be installed to support the sides of the pit and prevent collapse during excavation. This shall involve placing of wooden supports along the sides of the pit to maintain its shape and stability.

6. Installation of formwork

Formwork shall be erected to the required dimensions and securely supported. It shall be tight enough to prevent leakage of concrete.

7. Installation of reinforcement bars

Reinforcement shall be fixed in place in accordance with the drawings and Engineer's instructions. Steel shall be free from rust, oil and contaminants.

8. Concrete mix work

The concrete mix C30 shall be prepared as directed by the Engineer for the next phase of the underpinning process.

9. Concrete placing

The concrete shall be placed into the excavated pits, ensuring it completely fills the pits and forms a solid foundation. Concrete shall be evenly distributed and compacted to eliminate air pockets. Curing shall be done as approved by the Engineer.

10. Backfilling

After the concrete has gained sufficient strength and temporary supports removed, backfilling shall be placed in layers and compacted to the densities specified by the Engineer.

15607 MEASUREMENT AND PAYMENT

Item: Pile Underpinning

Unit: No.

The method of measurement for this repair method shall be by the number of repaired pile underpinning, 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.

15700: JACK PILE UNDERPINNING

15701 SCOPE OF SECTION

This section covers jack pile underpinning which involves the excavation of soil, settlement of steel toe/pile & jack, penetration of pile, welding next pile, adjustment (level) of height of pile, removal of hydraulic jack, jack up, filling with soil, concrete production and placement. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

15702 GENERAL

This method involves driving steel piles into the ground and using hydraulic jacks to raise and support the foundation. It is designed to provide additional support and stability to an existing foundation that may have settled, weakened or require reinforcement.

15703 DEFINITIONS

The jack pile method of underpinning is done where the conventional underpinning is uneconomical because of the depth of suitable bearing capacity of the subsoil. It is a technique used to strengthen an existing structure foundation.

15704 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete
BS EN 1992	Design of reinforced concrete structures
BS 8004	Code of practice for foundations

15705 MATERIALS

1. Anchors or Tendons
2. Formwork
3. Cementitious mortar or adhesive
4. Grout
5. Cement
6. Aggregates (Fine and Coarse)
7. Water

8. Reinforcement bars
9. Steel sections (piles)

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

15706 ORDER OF WORKS

1. Excavation of soil

The soil at the predetermined locations around the perimeter of the existing foundation shall be excavated.

2. Settlement of steel toe/pile & jack

The steel toe or pile and the hydraulic jack shall be placed at the excavated locations.

3. Penetration of pile

A specialized equipment approved by the Engineer shall be used to drive the steel piles into the ground at the marked locations until they reach stable soil or rock.

4. Welding next pile

The next section of the pile shall be welded to the driven pile, ensuring a continuous and stable connection. This process shall be repeated until the desired depth is reached.

5. Adjustment of height of pile

The height of the pile shall be adjusted in accordance with the specifications and as instructed by the Engineer to ensure it aligns with the required elevation and provides adequate support to the structure.

6. Removal of hydraulic jack

Once the piles are in place and the height is adjusted, the hydraulic jack shall be removed.

7. Jacking up

The hydraulic jacks shall be placed on top of the driven piles to support the existing foundation. Hydraulic pressure shall be applied to gradually raise the foundation and transfer the load from the original foundation to the newly installed piles.

8. Concrete mix work

The concrete mix C30 shall be prepared as directed by the Engineer for the next phase of the underpinning process.

9. Concrete placing

The concrete shall be placed into the excavated pits, ensuring it completely fills the pits and forms a solid foundation. Concrete shall be evenly distributed and compacted to eliminate air pockets. Curing shall be done as approved by the Engineer.

10. Backfilling

Backfilling shall be done with suitable material as directed by the Engineer.

15707 MEASUREMENT AND PAYMENT

Item: Jack Pile Underpinning
Unit: No.

The method of measurement for this repair method shall be by the number of jack pile underpinning, 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.

**15800: ROOT OR ANGLE PILING
UNDERPINNING**

15801 SCOPE OF SECTION

This section covers works associated with root or angle piling underpinning, including drilling with air flushed percussion auger, boring with concrete drilling equipment, installation of steel lining, mixing and placing of concrete into lined, inclined pile bores. All repair works shall be performed in accordance with the drawings, specifications and Engineer's instructions.

15802 GENERAL

Root or angle piling underpinning shall be undertaken where existing foundation require strengthening, stabilization or additional support due to weak soils, scour, settlement or increased loading demands. The completed inclined piles shall provide lateral and vertical support contributing to improved foundation stability.

15803 DEFINITIONS

Root or angle piling is a strengthening technique in which piles are drilled and constructed at an inclination (angled) to enhance lateral resistance, increase load bearing capacity or stabilize structures in challenging soil conditions or areas experiencing foundation distress.

15804 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of Kenyan Standards, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete
BS EN 1992	Design of reinforced concrete structures
BS 8004	Code of practice for foundations

15805 MATERIALS

1. Anchors or tendons
2. Formwork
3. Cementitious mortar or adhesive
4. Grout
5. Cement
6. Aggregates (Fine and coarse)
7. Water
8. Reinforcement bars
9. Steel sections (piles)

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

15806 ORDER OF WORKS

1. Drilling with air flushed percussion auger

Holes shall be drilled at the predetermined locations and angles using an air flushed percussion auger. This method ensures that the holes are clean and free of debris, allowing for accurate placement of the piles.

2. Boring using concrete drilling equipment

Concrete drilling equipment shall further bore the holes to the required depth and diameter as shown in the drawings. This ensures that the holes are properly prepared for the installation of the steel lining.

3. Installation of steel lining

Steel lining shall be installed immediately after boring to maintain bore holes stability. The steel lining helps to maintain the integrity of the holes and prevents collapse during the subsequent steps. It shall be of the specified thickness and length, securely seated and aligned with the design inclination.

4. Concrete mixing

The concrete mix C30 shall be prepared as directed by the Engineer for the next phase of the underpinning process.

5. Concrete placing

The concrete shall be placed into the steel lined holes, ensuring that it is evenly distributed and compacted to eliminate air pockets. Curing shall be done as approved by the Engineer.

6. Backfilling

Backfilling shall be done with suitable material as directed by the Engineer.

15807 MEASUREMENT AND PAYMENT

Item: Root or Angle Piling Underpinning

Unit: No.

The method of measurement for this repair method shall be by the number of root or angle piles constructed, 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.

15900: PYNFORD STOOL UNDERPINNING

15901 SCOPE OF SECTION

This section covers pynford stool underpinning which involves drilling holes in the wall, insertion and pinning of stools, removal of brickwork between pinned stools, reinforcement fabrication and placing around the pinned stools, formwork erection and beam casting, and formwork removal. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

15902 GENERAL

Pynford stool underpinning is a technique that is used to stabilize and strengthen foundations of existing structures, particularly in situations where conventional underpinning methods are not suitable or practical.

15903 DEFINITIONS

The pynford stool method is a technique used to support and stabilize existing structures that have experienced subsidence or require additional foundation support.

15904 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete
BS EN 1992	Design of reinforced concrete structures
BS 8004	Code of practice for foundations

15905 MATERIALS

1. Anchors or tendons
2. Formwork
3. Cementitious mortar or adhesive
4. Grout
5. Cement
6. Aggregates (Fine and coarse)
7. Water
8. Reinforcement bars

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

15906 ORDER OF WORKS

1. Drilling of holes

Holes shall be drilled on the wall at the predetermined locations to receive the steel or precast concrete stools.

2. Insertion and pinning of stools

The stools shall be inserted into the drilled holes and pinned to the soffit of the brickwork over the opening to provide temporary support to the structure during the underpinning process.

3. Brickwork

The brickwork between the pinned stools shall be removed to leave the wall supported on the pinned stools to create space for the next steps of the underpinning process.

4. Reinforcement fabrication and placing

The reinforcement shall be fabricated and placed around the pinned stools to enhance the structural integrity of the underpinning.

5. Formwork erection and beam casting

The formwork shall be erected around the reinforced area and the beam casted.

6. Concrete mixing

The concrete mix C30 shall be prepared as directed by the Engineer.

7. Concrete placing

The concrete shall be placed, ensuring that it is evenly distributed and compacted to eliminate air pockets. Curing shall be done as approved by the Engineer.

8. Formwork removal

Once the concrete beam has set, the formwork shall be removed and the beam allowed to cure. After curing, the beam shall be pinned to the underside of the wall to complete the underpinning process.

15907 MEASUREMENT AND PAYMENT

Item: Pynford Stool Underpinning

Unit: No.

The method of measurement for this repair method shall be by the number of pynford stools underpinned, 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.

**16000: UNDERPINNING
COLUMNS/PIERS/PILES**

16001 SCOPE OF SECTION

This section covers the underpinning columns/piers/piles. It involves excavation, placement of jack piles or concrete bearing pads, positioning of hydraulic jacks, installations of precast concrete or steel beams, jacking and installation of underpinning system and subsequent backfilling.

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

16002 GENERAL

The process of underpinning columns/piers or piles involves stabilizing and existing building or structure foundation by installing additional support columns or piles.

16003 DEFINITIONS

Underpinning columns/piers or piles refers to a structural reinforcement technique used to strengthen and stabilize the substructure element of an existing building or structure when the original substructure is not adequate.

16004 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete
BS EN 1992	Design of reinforced concrete structures
BS 8004	Code of practice for foundations
BS 5950/ BS EN 1993	Design of steel structures

16005 MATERIALS

1. Precast concrete columns/ piles
2. Formwork
3. Cementitious mortar or adhesive
4. Grout
5. Cement
6. Aggregates (Fine and coarse)
7. Water

8. Reinforcement bars
9. Helical piles-screw like steel shafts
10. Epoxy resin

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

16006 ORDER OF WORKS

1. Cleaning

Clean the work area around the foundation to ensure adequate space for machinery and equipment.

2. Excavation

Excavate the area around the existing foundation in a controlled and systematic manner to expose the foundation to the required depth while maintaining the structures stability.

3. Settlement of Jack piles / concrete bearing pad

The jack piles or a concrete bearing pad shall be installed at the predetermined locations. Ensure that the bearing surfaces are properly levelled and have attained the necessary support strength to support both equipment and structural members.

4. Settlement of hydraulic jacks

The hydraulic jacks shall be placed on top of the jack piles or concrete bearing pad. Each shall be aligned to the required elevation and tested for capacity and functioning prior to load engagement.

5. Settlement of precast concrete beams / steel beams

The precast concrete beams or steel beams shall be installed to provide additional support to the structure. These beams shall be placed on top of the hydraulic jacks and aligned with the existing foundation.

6. Settlement of precast concrete short beams

The precast concrete short beams shall be placed between the main beams to distribute the load evenly and provide further stability to the structure.

7. Connection

The beams shall be connected using high strength bolts, clamps or welded connections as specified.

8. Jack up

The structure shall be jacked up using the hydraulic jacks. This process shall be monitored to ensure even lifting and proper load transfer from the existing foundation to the newly installed support system.

9. Installation of underpinning system

The chosen columns/ piles shall be installed in the excavated holes adjacent to the existing foundation ensuring the columns reach the required depth for stability.

10. Grouting or filling

Fill any holes around the columns with grout or concrete to provide additional stability and proper positioning.

11. Load transfer

Slowly shift the load from the existing structure onto the newly installed support columns until it is evenly distributed and the structure is level. Then remove the jacking system.

12. Backfilling

Backfilling shall be done with suitable material as directed by the Engineer.

16007 MEASUREMENT AND PAYMENT

Item: Underpinning columns/piers/piles

Unit: No.

The method of measurement for this repair method shall be by the number of underpinning columns/piers/piles constructed, 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.

**16100: MUD JACKING
(SLAB JACKING) REPAIR METHOD**

16101 SCOPE OF SECTION

This section covers mud jacking (slab jacking) repair which involves drilling holes into a sunken concrete slab and pumping a cement-based slurry underneath to lift it back to its original position. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

16102 GENERAL

The mud jacking process begins with drilling patterned holes in the concrete slab, placed 600mm to 1200mm apart and approximately 50mm in diameter. Next, a cement slurry is injected under high pressure through these holes. The pressure from the slurry fills the voids beneath the slab and forces it to rise, restoring it to its original level.

16103 DEFINITIONS

Slurry is a semi-liquid mixture, typically consisting of fine particles of materials such as cement, clay, or coal suspended in water. It is commonly used in construction and industrial processes to transport solids or fill voids.

16104 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete
BS EN 12274	Slurry surfacing test methods

16105 MATERIALS

1. Cement
2. Aggregates (Fine and coarse)
3. Water
4. Additives (Optional)

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

16106 ORDER OF WORKS

1. Concrete plate drilling

Holes of about 600mm to 1200mm apart, and approximately 50mm diameter shall be drilled in the concrete slab. The number of holes shall vary depending on the extent of the concrete damage and as instructed by the Engineer.

2. Slurry injection

Slurry mix shall be prepared by combining Portland cement with water and other materials such as sand, dirt, or limestone aggregate. This mixture shall then be injected under high pressure through the drilled holes. The pressure from the slurry fills the voids beneath the slab and forced it to rise, restoring it to its original level.

3. Filling in drilled holes

Once the slab is levelled, the slurry mixture shall be cleaned from the holes and refilled with fresh concrete. Any cracks shall be repaired by caulking (*refer to section 11100 of this specification*) within the concrete approach slab to prevent water penetration and additional soil erosion.

16107 MEASUREMENT AND PAYMENT

Item: Mud Jacking (Slab Jacking) Repair Method

Unit: m² and m³

The method of measurement for this repair method shall be by the area of slab drilled and volume of slurry used for repair, checked and approved by the Engineer.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for the works excluding drilling of the holes as detailed in plans and specifications.

16200: POLYURETHANE CONCRETE RAISING METHOD

16201 SCOPE OF SECTION

This section covers polyurethane concrete raising which involves concrete plate drilling, polyurethane injection, and filling in drilled holes.

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

16202 GENERAL

The polyurethane concrete raising method begins with drilling a hole through the concrete slab into the subgrade, compressing loose soils and raising the concrete slab to the desired level.

16203 DEFINITIONS

Polyurethane is a versatile polymer composed of organic units joined by urethane (carbamate) links. It is created through the chemical reaction between polyols and diisocyanates. Polyurethane can be tailored to either be flexible or rigid, making it suitable for a wide range of applications, including foams, elastomers, and coatings.

16204 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete
BS EN 13165	Polyurethane products

16205 MATERIALS

1. Polyurethane
2. Non shrink mortar
3. Water

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

16206 ORDER OF WORKS

1. Concrete plate drilling

A hole shall be drilled through the concrete slab into the subgrade. This hole shall serve as the entry point for the polyurethane foam.

2. Polyurethane injection

A tapered delivery port shall be installed into the drilled hole and the injection gun connected to the port. The injection gun shall deliver the polyurethane material through the port and slab. The polyurethane foam shall expand, compressing loose soils and raising the concrete slab. The air-purged gun shall keep the injection port open between the injections, allowing the foam to expand before injecting more material.

3. Filling in drilled holes

Once the slab is raised to the desired level, the injection ports shall be cleaned and the drilled holes refilled with fresh concrete. This shall ensure a smooth and even surface, ready for use.

16207 MEASUREMENT AND PAYMENT

Item: Polyurethane Concrete Raising Method

Unit: m² and m³

The method of measurement for this repair method shall be by the area of slab drilled and volume of polyurethane injected, checked and approved by the Engineer.

Payment shall be full compensation for provision for all materials, equipment, labour, related services necessary for the works excluding drilling for the holes as detailed in plans and specifications.

16300: GRASSING

16301 SCOPE OF SECTION

This section covers grassing which involves the preparation of surface and planting and maintenance of grass. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

16302 GENERAL

Grassing is a method for protecting the embankment fills from erosion caused by wind or surface run offs.

16303 DEFINITIONS

Grassing the provision of vegetation cover to minimize effect of surface run off on embankments.

16304 APPLICABLE STANDARDS

Grassing shall be in accordance with the provisions of the relevant clauses of the following British Standard:

BS 4428:1989	Code of practice for general landscape operations (excluding hard surfaces)
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16305 MATERIALS

1. Manure
2. Suitable soil
3. Grass seeds
4. Water

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

16306 ORDER OF WORKS

1. Prepare slope to receive grass seed,
2. Use mats to stabilize and plant grass seed,
3. Water the matted area regularly,
4. Mow and maintain slopes.

16307 MEASUREMENT AND PAYMENT

Item: Grassing
Unit: m²

The method of measurement for this repair method shall be by the area of grassing, 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.

16400: STONE PITCHING/ REVETMENT

16401 SCOPE OF SECTION

This section covers stone pitching/revetment which involves the preparation of the slope, toe-beam construction, laying of masonry stones, preparation and placement of mortar and curing. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

16402 GENERAL

Stone pitching involves placing of medium-sized stones into mortar to protect slopes, channels and embankments against erosion. It is suitable for slopes with gradients from 5% to 35%, particularly in areas experiencing heavy seepage, flood risks, or where vegetation is inadequate.

16403 DEFINITIONS

Stone pitching is protective layer of medium-sized stones placed on the slope or embankment surface with mortar intended to control erosion, stabilize the slope and direct surface run off.

16404 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete

16405 MATERIALS

1. Masonry stones
2. Cement
3. Fine aggregate
4. Coarse aggregate
5. Suitable fill soil
4. Water

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

16406 ORDER OF WORKS

1. Slope preparation

The slope shall be cleared of vegetation, loose debris, topsoil and unstable material and trimmed to a uniform profile as specified in the drawings. The slope shall then be compacted to provide a firm surface.

2. Laying filter layer

A layer of approved granular material shall be spread over the prepared slope as directed by the Engineer.

3. Toe-beam installation

A C30 concrete toe-beam shall be constructed at the bottom of the slope to prevent stones from dislodging.

4. Laying of stones

Stones shall then be arranged starting from the toe-beam upwards as instructed by the Engineer.

5. Filling of voids

Mortar shall be evenly placed to ensure all the voids are filled.

6. Curing

Curing shall be done as directed by the Engineer.

16407 MEASUREMENT AND PAYMENT

Item: Stone pitching

Unit: m²

The method of measurement for this repair method shall be by the area of stone pitching, 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.

**16500: REINSTATEMENT OF RIVER
BED LEVEL USING GROUND SILL**

16501 SCOPE OF SECTION

This section covers reinstatement of damaged or scoured river bed level using ground sill. It involves river closure works, excavation of scoured area, foundation works, setting of formworks, concrete mixing, concrete placing, settlement of blocks, curing, and removal of formwork. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

16502 GENERAL

Ground sill repair primarily involves maintenance and rehabilitation measures to protect a bridge's foundation from river bed erosion (scouring).

16503 DEFINITIONS

Ground sill is a river structure built across a river to control water flow and sediment deposition, thereby preventing degradation of the riverbed.

16504 APPLICABLE STANDARDS

The material shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, AASHTO, British Standard or Eurocode:

KS EAS 18-01	Cement
BS 812/ AASHTO M6-08	Methods for determination of particle size and shape
BS 822/ BS EN 12620/ BS EN 14205	Testing and specification for aggregates from natural sources for concrete
BS 1200/ EN 1992	Building sands from natural resources
BS 3148/ BS EN 1008/ KS 2846	Water for making concrete

16505 MATERIALS

1. Concrete blocks or quarry stones
2. Coarse and fine aggregates
3. Cement
4. Water
5. Reinforcement bars
6. Additives (Rapid hardeners)

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

16506 ORDER OF WORKS

1. River closure works

The river shall be temporarily closed off using cofferdam to allow for the safe execution of the construction activities. This shall involve the installation of barriers or cofferdams to divert the water flow.

2. Excavation of scoured area

The scoured or eroded area of the riverbed shall be excavated to remove loose or unstable material.

3. Foundation work

The foundation of the ground sill shall be constructed. This shall involve laying a concrete base or other stabilising materials to ensure a solid foundation for the structure.

4. Setting of formwork

Formwork shall be set up to receive the concrete.

5. Concrete mixing

The concrete mix C30 shall be prepared as directed by the Engineer.

6. Concrete placing

The concrete shall be placed as directed by the Engineer.

7. Settlement of blocks

Concrete blocks shall be settled into place as part of the ground sill structure to help stabilise the riverbed and reduce erosion.

8. Curing

The concrete shall be cured as approved by the Engineer for the durability of the structure.

9. River closure removal works

After curing, the temporary river closure measures shall be removed to allow the river back to its course.

16507 MEASUREMENT AND PAYMENT

Item: Ground sill

Unit: m²

The method of measurement for this repair method shall be by the area of ground sill constructed, checked and approved by the Engineer.

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

16600: PRESSURE INJECTION OF CRACKS UNDERWATER

16601 SCOPE OF SECTION

This section covers pressure injection of cracks underwater. It involves setting up of scaffolding, cleaning of cracks, installation of pipe fitting, sealing of cracks at the surface, fitting of injector, injection of epoxy, curing of injected material, and removal of scaffolding. All repair work shall be performed in accordance with the drawings, specifications and Engineer's instructions.

16602 GENERAL

This method is used to repair non-moving cracks in concrete structures located underwater. It involves injecting resin-based material into the cracks to restore structural integrity.

16603 DEFINITIONS

Pressure injection of cracks underwater is a technique in which a suitable underwater grade grout or epoxy or resin-based material is injected into submerged cracks restoring structural continuity and preventing further water ingress.

16604 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)

16605 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.

16606 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.

2. Installation of pipe fitting

The pipe fittings shall be fixed at instructed intervals along the length of each 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 pipefitting 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. 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 as specified by the manufacturer and directed by the Engineer.

6. Curing of injected material

Surface coating shall be applied for curing as specified by the manufacturer and 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

16607 MEASUREMENT AND PAYMENT

Item: Epoxy injection

Unit: m

Measurement shall be in linear meters for the crack length repaired.

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

16700: UNDER WATER CONCRETE REPAIR

16701 SCOPE OF SECTION

This section covers all activities related to under water concrete repair including installation of scaffolding, removal of defective concrete, surface preparation of concrete and reinforcement, formwork fixing, application of epoxy bonding agents, preparation and placing of concrete or polymer modified repair materials, curing and removal of temporary works. All repair works shall be performed in accordance with the drawings, specifications and Engineer's instructions.

16702 GENERAL

Underwater concrete repair shall involve restoring structural integrity and durability by replacing damaged or deteriorated concrete sections with fresh concrete or polymer modified mortar of equal or higher compressive strength by patching or sectional repair/ plastering.

16703 DEFINITIONS

Patching is a method for repairing small damaged and deteriorated areas where defective concrete is removed and replaced with fresh mortar or concrete.

Sectional repair is a method used for larger damaged and deteriorated areas where defective concrete is removed and the exposed reinforcement treated.

16704 APPLICABLE STANDARDS

The materials shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, ASTM, British Standard or Eurocode:

KS EAS 18-01.	Cement
ASTM C39, BS 6319-2	Compressive Strength
ASTM D7234, BS 6319-4	Bonding Strength to Concrete
ASTM C39, BS 6319	Bleeding Rate
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

16705 MATERIALS

1. Ordinary cement
2. Additives (Admixtures)
3. Polymer Cement- (PCM powder, PCM emulsion)
4. Concrete nail
5. Bonding agent to concrete (Epoxy bonding)

6. Fine aggregates

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

16706 ORDER OF WORKS

1. Removal of defective concrete

All damaged concrete shall be removed from the damaged areas using suitable tools such as hammers, chisels or underwater power tools and loose debris cleaned.

2. Furnishing formwork

Formwork shall be installed around the repair zone to contain the concrete or mortar as directed by the Engineer.

3. Corroded rebar treatment

Rust on the rebar shall be removed and a corrosion inhibitor applied evenly to the rebar according to the appropriate specifications for each material.

If there is significant sectional loss of the rebar due to corrosion, they shall be replaced or supplemented, and the unnecessary embedded steel materials, such as spacers and temporary bars, removed.

4. Plastering

The plastering method shall be applied to relatively small-scale sectional repairs as directed by the Engineer. The primer shall be applied and allowed to harden. 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.

For overhead or soffit repairs, light weight Portland Cement Mortar (PCM) shall be used to prevent sagging.

5. Curing

The plastered section shall be cured in accordance with the Engineer's instructions.

16707 MEASUREMENT AND PAYMENT

Item: Under Water Concrete Repair

Unit: m³

Measurement shall be based on cubic meter for the volume of concrete repaired.

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

16800: COFFERDAM

16801 SCOPE OF SECTION

This section covers the work related to the construction, maintenance and removal of cofferdams using sheet piles which includes driving steel sheet piles, installation of waling and struts (bracing system), dewatering, inspection of the cut-off structure, executing the intended works inside the cofferdam, and removal after completion. All works shall be performed in accordance with the drawings, specifications and the Engineer's instructions.

16802 GENERAL

A cofferdam is a temporary watertight enclosure built within rivers, streams or other water bodies to create a dry environment for construction.

16803 DEFINITIONS

Sheet pile is interlocking steel sections driven into the ground to form a continuous cutoff wall.

Waling is horizontal member installed along the inside face of sheet piles to distribute reaction forces from struts.

Strut is compression member installed horizontally to resist inward movement of sheet piles due to lateral pressure.

Dewatering is removal of water from within the cofferdam using pumps.

16804 APPLICABLE STANDARDS

The material and construction methods shall be in accordance with the provisions of the relevant clauses of the Kenyan Standards, ASTM Specifications, British Standard or Eurocode:

KS EN 1993	Design of Steel Structures
BS EN 12063	Execution of Steel Sheet Piling Works
KS 02-104	Structural Steel
ASTM A328 / A572	Steel Sheet Piles
BS 5950	Structural Steel Design
BS EN 10025	Hot Rolled Products of Structural Steels
BS EN 1997	Geotechnical Design

16805 MATERIALS

1. Steel sheet piles (Larssen, U-type or Z-type)
2. Waling / Walers (Steel H-beams or channels)
3. Struts (Steel pipes, H-beams, or other approved members)
4. Tie rods and connectors
5. Sealing materials (bentonite bags, sandbags, geotextile)
6. Bolts, nuts and fasteners

All materials shall comply with the specifications and be approved by the Engineer prior to installation.

16806 ORDER OF WORKS

1. Site preparation

The cofferdam location shall be cleared and access routes and working platforms prepared as instructed by the Engineer.

2. Survey and setting out

The alignment of the sheet pile wall shall be set out accurately following the approved drawings.

3. Driving of sheet piles

Sheet piles shall be driven using a vibrator, drop hammer or hydraulic driver in a manner ensuring that the interlocks are clean and undamaged as approved by the Engineer.

4. Driving is vertical and within tolerance

Sheet piles reach the required penetration where refusal is encountered, corrective measures shall be applied as instructed by the Engineer.

5. Installation of waling

Walers shall be installed at designated levels to distribute loads. They shall be aligned, securely connected and tightened to the required specifications.

6. Installation of struts

Struts shall be installed horizontally to brace the sheet piles. The spacing, section size, preloading, and axial alignment shall follow the approved design. Struts shall be checked regularly during works to avoid overstressing.

7. Sealing of cofferdam base

The base shall be sealed using sandbags, geotextile, clay or bentonite materials to minimize seepage as directed and approved by the Engineer.

8. Dewatering

Pumps shall be used to remove water from the inner side of the cofferdam. The water level shall be controlled to maintain a safe, dry working area. Continuous monitoring for uplift, piping or excessive seepage shall be performed.

9. Inspection

The Engineer shall inspect the cofferdam for lateral movement, settlement, leakage, strut deformation, structural stability and repairs or reinforcement shall be implemented immediately if any is detected.

10. Execution of intended works inside cofferdam

The intended permanent works shall be executed safely within the stabilized cofferdam.

11. Removal of cofferdam

After completion and approval of permanent works: dewatering shall be stopped, struts and walers shall be removed, sheet piles shall be extracted using approved pulling equipment, the area shall be restored and debris removed.

Note: All removals shall follow a reverse sequence of installation.

16807 MEASUREMENT AND PAYMENT

Item:	Area of sheet pile wall
Unit:	m ²
Item:	Length of sheet pile installation
Unit:	m

The method of measurement for this cofferdam shall be by the area of sheet pile wall and length of sheet pile installation checked and approved by the Engineer.

Payment shall be full compensation for all materials, equipment, labour, design, dewatering, maintenance, removal, and all incidental works necessary for a complete installation as shown in the drawings and specifications.

