7. QUALITY CONTROL, MONITORING AND SUPERVISION

7.1 QUALITY CONTROL

Quality is defined as:

- Degree of goodness
- Conformance to requirements
- Zero defects
- Fitness for purpose
- Consistent conformance to expectation
- Doing things right the first time
- Quality is the totality of characteristics of an entity that bears on its ability to satisfy stated and implied needs

Quality Control concerns the operational means to fulfill the quality requirements. It detects the non-conformity and verifies the conformity. Quality control includes the following stages:

- Incoming goods, services and information
- In-process
- End product

Facts and Misconceptions regarding Quality

- Quality is not grade
- Quality costs more, but lack of quality costs even more
- Quality is a means of achieving project success. It is not the goal in itself
- Process quality is more than product quality
- Quality standards do not demand the best quality, they establish the minimum requirements to be achieved
- Quality does not happen by accident, it has to be properly planned and implemented

7.2 QUALITY MANAGEMENT

- Quality Control
- Quality Assurance
- Total Quality Management

Quality management includes Quality Assurance (QA) and Quality Control (QC) as well as other concepts of quality planning, quality policy and quality improvement. Total Quality Management (TQM) develops these concepts as a long-term global management strategy and the participation of all members of the organization for the benefit of the organization itself, its members, its customers and society as a whole.

Client and Quality

- What does the client want ? The client's brief and commitment is most essential
- Due to his unique requirements and constraints, the client has to provide clear instructions, timely decisions and assist the project management team
- Continual effort to achieve better and improved quality performance is vital

Conflict Leads to:

Quality management tools and techniques:

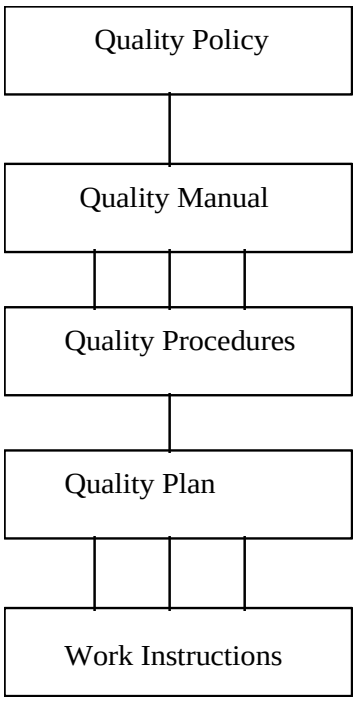
- Process sequence flow chart - to know what is the process
- Tally chart/check sheets - to know how often what goes wrong
- Histogram - to obtain meaningful pictures of data
- Pareto analysis - to find the vital few from the trivial many
- Cause and effect diagram - brainstorming and teamwork approach to find out cause and effect.
- Fault tree analysis
- Quality Function Deployment (QFD) - to best capture clients requirements.
- Statistical process control (SPC) etc.

7.3 QUALITY PLAN

A Quality Plan (QP) is a document setting out the specific quality practices, resources, and sequences of activities relevant to a particular product, service, contract, or project. It should define:

- The quality objectives to be attained.
- The specific allocation of responsibilities and authority during the different phases of the project.
- The specific procedures, methods and work instructions to be applied.
- Suitable testing, inspection, and audit programs at appropriate stages.
- A method of modification for the quality plan as the project proceeds.
- Other measures necessary to meet the objectives.

7.4 QUALITY DOCUMENTS



7.5 QUALITY ASSURANCE

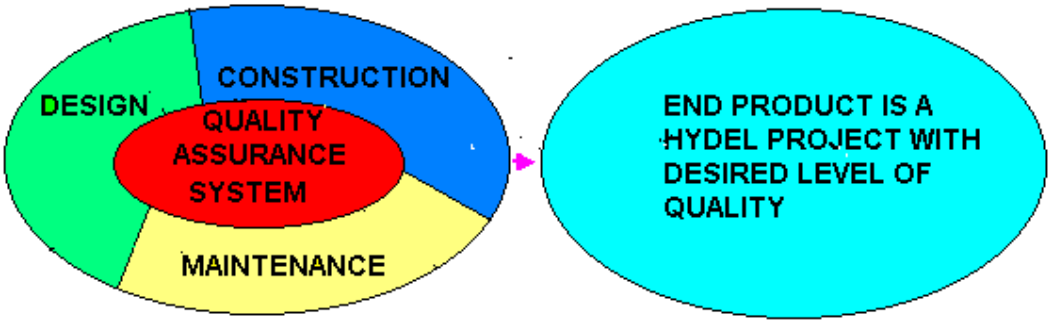
Quality assurance:

- aims at providing confidence in fulfilling the requirements both within the organization and externally to customers and authorities.
- is a systematic way of ensuring those organized activities happen in a way that they are planned.
- is concerned with anticipating problems and with creating the attitudes and controls that prevent problems from arising.
- firstly, aims to impart confidence to the client assuring that his needs will be consistently met (external quality assurance). Secondly, it aims to achieve quality through systematic and planned actions avoiding "fire-fighting or crisis management" (internal quality assurance).
-

Elements of Quality Assurance System

- Quality Assurance System
- Requirements of Project
- Choice of Quality Materials and Design
- Development of Technical Specification and Acceptance Criteria
- Choice of Construction Method; Equipment/Plant
- Field supervision and Quality Control
- Assessment of Quality of Finished Work
- Periodic Inspection and Maintenance Measures

Importance of Quality Assurance in a developing economy



Elements of Quality Assurance System

- Assessment of the project's requirements.
- Development of technical specifications and acceptance criteria.
- Choice of quality materials and design.
- Choice of construction method; Equipment/ Plant.
- Field supervision and quality control.
- Assessment of quality of completed project.
- Periodic Inspection and Maintenance measures.

Preparation of a Quality Assurance Plan

- Clearly defining the objectives
- Enumerating the activities involved
- Incorporating the requirements of quality in each activity and providing for a fail-proof safeguard, if any, and
- Laying down the surveillance plan, checks and penalties for each apprehended lapse and omission

Activities Involved in Achieving Quality Assurance Plan

- Pre-design activities
- Design
- Construction
- Maintenance

Pre-design Activities

- Defining the objectives and scope
- Consideration of alternative proposals
- Planning and programming
- Organization and personnel
- Training and introduction
- Quality record and documentation
- Surveillance and review proposals
- Corrective action proposed

Design Activities

- Surveys and investigation
- Decision about services and their procurement
- Feasibility report
- Technical appraisal
- Specifications
- Drawings
- Estimates
- Tender documents

Construction Activities

- Planning for procurement of services
- Pre-qualification of supervision Consultants
- Pre-qualification of the Contractor
- Invitation for tender
- Tender evaluation, negotiation and award of work
- Drawing up and finalization of work program
- Plan for management of execution including -
- Scheduling of activities for supervision, inspection and payment

Maintenance

- Quality standards
- Performance standards
- Quality assessment

7.6 QUALITY AND COST

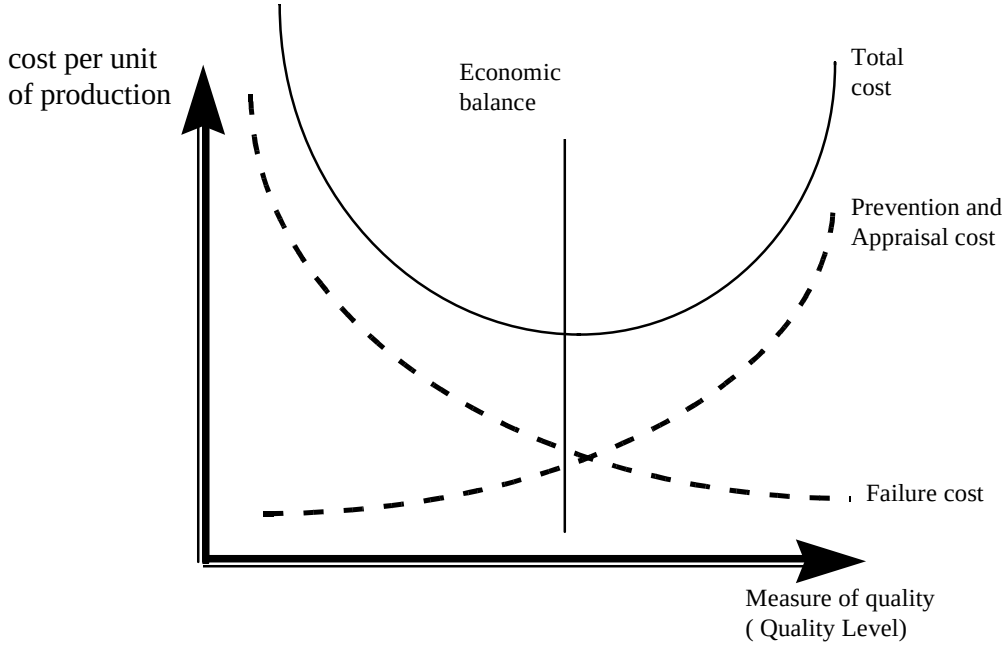
Quality Management Cost

Prevention cost (cost involved in activities to ensure right first time performance) and Appraisal cost (cost involved in activities that check whether right first time is achieved).

Failure Cost

Cost involved in activities that result from not conforming to right first time and includes internal, external and intangible quality cost. A quality costing system is very much important since it quantifies the cost of failure.

Quality is Free



Quality Organization

- Client-oriented and not product-oriented
- Quality the driver
- Focus on medium to long-term gain
- Understanding that quality costs less
- Quality is everyone's responsibility in the organization
- Continuous improvement and rewarding culture
- Flat and integrated organization structure

7.7 QUALITY AND STANDARDS

Standards could be:

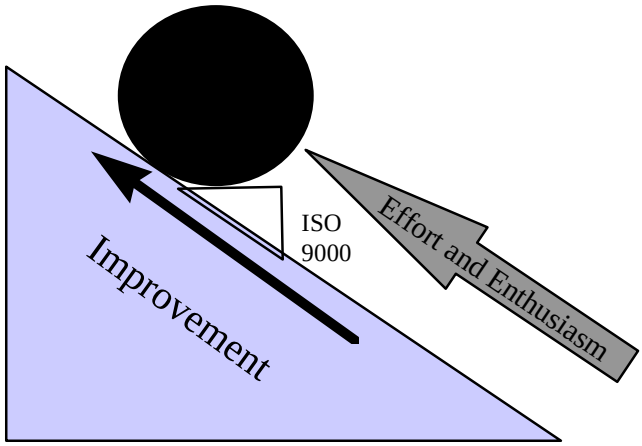
Specification of process, product and system

Methods, measurement, testing, sampling and analysis

Glossaries, symbols and classification

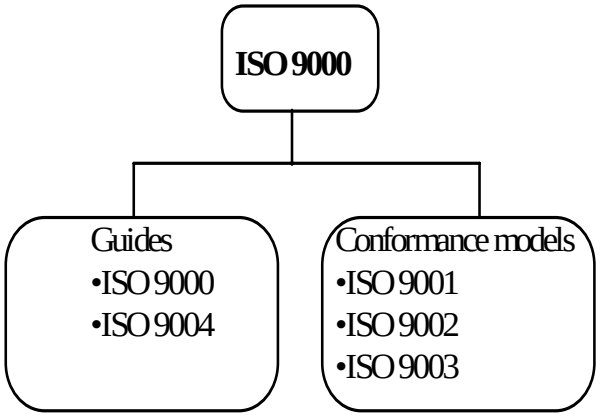
Code of practice, guides and recommendations

7.8 ISO 9000 AND QUALITY SYSTEMS



ISO 9000 prevents losing ground

7.9 ISO 9000 FAMILY



7.10 SHARING OF RESPONSIBILITY IN QUALITY CONTROL

Who is Responsible for Quality?

- The Owner
- The Designer
- The Contractor
- The Supervision Team

Position of Quality Control in the New Set-Up

- Changing Quality Concepts
- Total Quality Management: the Modern Concept
- Quality Circles
- Objectives
- Limitations

Responsibility for carrying out quality control and quality assurance is always a question!

8. QUALITY CONTROL, MONITORING AND SUPERVISION FOR TRAIL BRIDGE CONSTRUCTION

8.1 QUALITY CONTROL OF STEEL PARTS FABRICATION AND SUPPLY

Quality is defined as degree of goodness. It is conformance to the requirements. It is the totality of the characteristics of an entity that bears on its ability to satisfy the stated and implied needs. Quality Control is detection of non-conformity and verification of conformity. It concerns the operational means to fulfill the quality requirements. It has to be done at different stages: 1) material procurement, 2) fabrication process and 3) end product.

Quality Control denotes all those activities which are directed towards

- setting of quality targets
- appraisal of conformance
- taking corrective action where any deviation is noticed
- planning for improvements in quality.

8.1.1 Fabricated and Supplied Steel Bridge Parts

The in-charge of the technical section shall be responsible for quality control. He deputes the Quality Control Engineer (QCE) to check the quality of the steel parts, fabrication and laboratory testing of materials.

The QCE should be aware of the following specifications and points for controlling the quality:

8.1.1.1 Supply of Nuts/Bolts/Washers, thimbles, bulldog grips, G.I. wire and other fixtures

Nuts/Bolts/Washers: IS 1363, IS 1367 Part XIII
Buldoggrips : IS 2361, IS1367 Part XIII

Nuts/Bolts, thimbles, bulldog grips and other fixtures shall have to be strictly checked so that it is hot dip galvanized (minimum zinc coating 40μm). It can be judged by eye. The electroplated fixtures look bright and as very new, where as hot dip galvanized fixtures look dim and old. However, it should be checked by Deltascope to confirm the minimum zinc coating.

The points to be checked are:

- Quality of raw materials.
  The raw materials should meet the specifications. The supplier shall show the manufacturer's certificate. There should be a stamp or a logo of the manufacturer. And if in doubt, laboratory tests shall be carried out to confirm the specifications.
- Correctness of dimension.
  The dimensions must be checked. It should be noticed whether the sizes conform to the metric system. The threaded part in the bolts, the size of the washer holes, and the thickness of the bolt heads and washers have to be checked.
- Uniformity in all pieces.

Sometimes, the items are not uniform. There may be different head sizes of the bolts and nuts. Particularly, such differences may be present in big size nuts and bolts.

- Condition of the threads and mobility of nuts on the threads.
  The nuts must turn easily around the threaded parts of the bolts. There must not be any damage in the threads. The remaining burrs after galvanization must be absent. While removing burrs from the thread, the zinc coating must not be shaped.
- Presence of cracks, bends and other defects.

There are sometimes cracks and bends in the nuts, bulldog grips and thimbles. Such items must be rejected.

- Correct Assembly.
  The nuts, bolts and washers must fit in the positions they were designed for. The thimbles must fit the pin or anchor rod.

- Torque Test.
  The nuts, bolts must pass the specified torque test.

8.1.1.2 Fabrication of Steel Parts

Structural Steel: IS 226

At the fabrication stage followings has to be checked physically.

Raw steel sections should meet IS specification for steel grade Fe 410. Physical property test of raw steel sections shall be made fabricator-wise in case of package contract. In other cases it shall be carried out in bridge-wise basis. The samples taken shall be representative.

The points to be checked are:

- The fabricator guarantees that the raw materials meet the specifications. The low quality of the raw materials can be detected visually by their missing uniformity.
- The dimensions of the steel sections must be within a tolerance of +2.5%.
- It has to be checked whether heat process has been used for bending, straightening or flattening work. It must be cold process.
- The cutting work or holing work shall be as per the terms of the steelwork.
- Experienced and qualified welders must do the welding work.
- The use of templates and jigs is mandatory for welding of the assembly.
- The welding thickness and the lengths of the welded joints have to be verified with the drawing.
- The smoothness and finishing of the welding have to be checked.
- Avoid techniques which could cause distortions and embitterment of the steel.
- All welding slogs shall be removed because they do not react with zinc during galvanization.
- Sections should have corners cropped to allow free flow of zinc during galvanization.
- The edges of the angles should be sealed by pore-free welding to prevent penetration of pickle acids.
- Each member has to be labelled clearly indicating the drawing number and the part number but this must be done only after galvanization.
- Straight bars and plates shall be bundled.
- All bolts, nuts and other small and loose parts shall be packed in cases or strong bags and labelled (the weight of each bag should not exceed 50kg).
- In case of fabricated wire-mesh netting, check the dimensions and the galvanization.
- Storing of threaded parts shall be done with grease and jute covers after they are completed.
- The most important point is the assembly of the steel parts. The galvanized parts shall be assembled after galvanization.
- 100% of bridge parts shall be checked instead of sample checking.

8.1.1.3 Supply of Reinforcement Steel

IS 456, IS 1786

The points to be checked are:

- The supplier guarantees that the reinforcement steel meets the specifications.
- They should be clean and free of loose mill-scales, dust, loose rust and coats of paints, oil or other coating, which may destroy or reduce bonding with concrete.
- They should be cold bent.

- Welded joints or mechanical connections are not acceptable.
- Grinding should be done to make points in the anchor rods. All individual items have to be checked instead of doing a sample check.

8.1.1.4 Galvanization of Steel Parts

Check quality of Galvanization as below.

- **Galvanizing Process**
  Check the galvanizing plant and its set up to be ensured that all the galvanizing process is available and maintained.

- **Quality of Zinc**
  This can be checked by chemical testing of raw zinc used for the galvanization. Zinc content should not be less than 98.5%.

- **Quality of galvanization**

  By visual check the following :
  - Galvanized steel should be free from rust and black spots, acid traps, welding slags.
  - Galvanized coating should be free from ash, pimple and bulky deposition.
  - Galvanized coating should be continuous, smooth and evenly distributed as far as possible.
  - Zinc coat should be adherent. This can be checked by hammering or scratching.
    The Hangers of the cross beam or suspenders should pass the wrapping test. The test shall be done by wrapping the galvanized hangers/suspenders two round around the 26mm dia pipe or cable. There should not be any flake or crack so that any flakes of zinc can be removed by bare hand.
  - No zinc paint or aluminium paint is applied to hide rust spots. This is very unhealthy practice, which frequently applied by the galvanizers.
  - Zinc thickness can be measured by Deltascope. In our case zinc coat should not be less than 80 µm.
  - **Treatment of Threads**: Extra zinc on threads should be removed with a rotating wire brush immediately after galvanizing or with gas blow and cleaning with rotating brush if galvanization is already hardened. Re-threading of the galvanized parts is not permitted.
  - **Existence of Apparatuses and Laboratory**
    The plant must possess the required apparatuses such as temperature meter, PH meter, Hydrometer, etc. The Laboratory and documentation of measurements can be a basis for quality work.

8.2 QUALITY ASSURANCE BY THE FABRICATOR AND GALVANIZING PLANT

8.2.1 Fabrication of Steel Parts

Fabricators should provide the quality assurance on their part. For this, fabricators should maintain the in-process inspection and make QC logging. In-process inspection and QC logging should include from raw material up to the final product including all production process. In-process inspection and QC logging should be at following stages and as per formats given below.

- Raw material
- Material preparation
- Assembly
- Welding
- Galvanizing

Raw Materials
Test certificate should be provided by the manufacturer/supplier. All steel sections (steel grade Fe 410) should comply with following requirement.
Yield stress ≥ 250 N/mm^2
Tensile strength ≥ 410 N/mm^2
Elongation $\geq 23\%$

Material Preparation.

In-process Inspection Form should include the information as in table below for Steel Sections to be used for fabrication.

Raw Materials

S.no.	Date	Time	Particular	Section Size		Uniformity of Shape	Signature of QC Manager
				Thickness	Width		

- Permissible tolerance = ± 2.5%

Assembly

S.no.	Date	Time	Drawing No	Particular	Conformity with Drawing	Finishing	Signature of QC Manager

Welding

S.no.	Date	Time	Drawing No	Particular	Welding Quality	Distort -ion	Size	Post Welding preparation	Signature of QC Manager

Assembly Test

S.no.	Date	Time	Drawing No	Particular	Assembly Test	Remarks	Signature of QC Manager

8.2.2 Galvanization of Steel parts

Pickling (Acid Treatment)

S.no	Date	Time	Observed (Required: PH Value =1 to 3, Density = Max 1.2						Signature of QC Manager
			PH Value (PH Meter reading)			Density (Hydrometer reading)			
			Tank 1	Tank 2	Tank 3	Tank 1	Tank 2	Tank 3	

Pre-flux (Fluxing)

S.no.	Date	Time	Observed (Required Density = 1.10 to 1.15			Remarks
			Density (Hydrometer reading)			

Temperature of Zinc Bath

S.no.	Date	Time	Observed (Required = 450 to 470°C Density (Hydrometer reading)			Remarks

Zinc Coating

S.no.	Date	Time	Observed (Required = 80 μm)			Remarks

INSTRUCTION FORM FOR STEEL PARTS

Instructions to the Firm

Bridge No. & Name : _____	Type/Span : _____
District/VDC : _____	River : _____

Fabricator : _____	Completion Date : _____
Agreement Date : _____	Inspection Date : _____

The following bridge parts with details mentioned do not conform to the Specifications :

Item No.	Bridge Parts
1.	
2.	
3.	
4.	
5.	
6.	All the remaining works completed are satisfactory.

Please do rectification (Item nos. .....), replacement (Item nos. .....), re-fabrication (Item nos. .....), re-galvanization (Item nos. .....) within ..... days.

Fabricator: I do fully agree to strictly follow the above instructions.

	Fabricator/Representative	Inspected By
Name:		
Designation:		
Signature:		
Date:		

8.3 CONSTRUCTION MATERIAL

The construction materials needed to build a bridge are

- Cement (Ordinary Portland Cement commonly used for general construction works),
- Sand,
- Gravel,
- Stone
- Water.

Check at the site whether they satisfy the specifications described for them in Chapter 6.

8.4 CONSTRUCTION WORK

8.4.1 Inspection at Critical Construction Stages

The inspecting technician should visit the site during the following stages of the construction work in case of implementation through Community:

- Site selection and preliminary estimate of the local materials required.
- Layout and notice of detailed quantity of local materials
- Checking of the excavation work and the level of the ground for laying the foundations
- Handing over of "foreign materials" and checking of storing premises
- Placing of steel parts in the foundation
- Cable hoisting and sag setting
- Commencement of walkway fitting
- Final checking

The inspecting technician should visit the site during the following critical construction stages of the in case of implementation through the contractor:

New Construction

- Fabrication
- Bridge layout/Excavation
- Masonry work/Concrete Work
- Cable Hoisting
- Final Inspection

Major Maintenance

- Fabrication
- Painting works
- Final Inspection

In addition random site visits during the construction period is also necessary.

Further details are given in Chapter 8.4.2 below.

8.4.2 Quality Control Tools

8.4.2.1 Technical Specifications

Detailed technical specifications for working on Trail Bridges are given in the Quality Control Scheme Document. The contents of the technical specification are as below.

100 ENGINEERING PACKAGE

110 Desk Study
120 Survey
130 Special Geological Study
140 Socio-Economic Study
150 Design
160 Maintenance Survey
170 Maintenance Design

200 MATERIALS

210 Wire Ropes
220 Blasting Materials

300 STEEL WORK

310 Supply and Fabrication of Steel parts
311 Structural Steel
312 Reinforcement Steel
320 Supply of Thimbles
330 Supply of Bulldog Grips
340 Miscellaneous Supply
341 Wire mesh Netting
342 Sign Board
343 Bolts, Nuts & Washers
351 Hot Dip Galvanization

400 TRANSPORTATION

411 Materials and Equipment
412 Wire Ropes

500 CONSTRUCTION

510 Site Clearance
520 All Excavation
521 Soil
522 Soft Rock
523 Hard Rock (by Quarrying out)
524 Hard Rock (by Blasting)
525 Excavation in Shallow Water
530 Foundation Excavation
531 Soil (ref. 521)
532 Soft Rock (ref. 522)
533 Hard Rock by Quarrying out (ref. 523)
534 Hard Rock by Blasting (ref. 524)
535 Hard Rock by Chiseling
536 Back filling
540 Construction of Gabion
550 Concrete Works
555 Formwork
560 Masonry and Mortar Work
561 Dry Stone Masonry or Pitching
562 Cement Masonry (Incl. Pos. No. 563/64)
565 Cement Plaster

570 Erection and Finishing work
571/2 Erection of Towers/Truss Bridge
573/4 Cable Hoisting
575 Erection of Walkway
576 Coaltar Application
580 Surrounding Works
590 Site Installation and Supervision
591 Site Installation & Site Supervision

600 MISCELLANEOUS WORKS

610 Gabion Works
611 Dismantling of Gabion Boxes
620 Concrete and Masonry Work
621/2 Dismantling of Masonry/Concrete Structure
630 Pretensioning of Wire Ropes
640 Walkway Adjustments
641/2 Replacing/Adjustment of Suspenders
643/4 Replacing/Adjustment of Crossbeams
645/6 Dismantling/Refining of the Walkway
647/8 Dismantling/Replacement of Wire mesh Netting
650 Finishing Works
653 Rust Prevention by Repainting
660 Other Miscellaneous

8.4.2.2 Inspection Forms

There are standard forms developed for quality control, monitoring and supervision purposes. These forms are used during the visit of site at critical stages of the construction.

INSPECTION CERTIFICATE FOR STEEL PARTS

Bridge No. & Name: _____	Type/Span : _____
District/VDC : _____	River : _____

Fabricator : _____	Completion Date : _____
Agreement Date : _____	Inspection Date : _____

Description	**Anchorage Parts**		**Tower Parts**		**Suspender, Walkway Cross Beam**		**Deck**		**Nuts, Bolts, Washers & other fixtures**	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Raw materials conform to the specifications										
Sections confirm to specifications										
Straightening, holing, punching etc. conform to specification										
Galvanization conform to the specification										
Assembly test successful										

Steel Parts and fixtures : ☐ Acceptable ☐ not acceptable, refer to Instruction Form

Delivery is due on : _____

Important Note: The final acceptance of the steel parts will be made after the completion of the whole bridge by issuing the Work Completion Certificate.

	Fabricator/Representative	Inspected By
Name:		
Designation:		
Signature:		
Date:		

INSTRUCTION FORM FOR STEEL PARTS

Instructions to the Firm

Bridge No. & Name : _____	Type/Span : _____
District/VDC : _____	River : _____

Fabricator : _____	Completion Date : _____
Agreement Date : _____	Inspection Date : _____

The following bridge parts with details mentioned do not conform to the Specifications :

Item No.	Bridge Parts
1.	
2.	
3.	
4.	
5.	
6.	All the remaining works completed are satisfactory.

Please do rectification (Item nos. .....), replacement (Item nos. .....), re-fabrication (Item nos. .....), re-galvanization (Item nos. .....) within ..... days.

Fabricator: I do fully agree to strictly follow the above instructions.

	Fabricator/Representative	Inspected By
Name:		
Designation:		
Signature:		
Date:		

First Inspection

INSPECTION FORM
FOR BRIDGE LAYOUT AND FOUNDATION EXCAVATION

Bridge No. & Name : _____	Firm's Name : _____
Firm's Site In-charge: _____	Inspection Date : _____
Date of Agreement : _____	Target Bridge Completion Date : _____

Quality :

Items to be inspected	***Conforming to GA***		***Remarks***
	Yes	***No***	
A-B peg distance and bridge span			
Elevations of A & B and BMs			
Profile of Bridge Axis			
Bridge Layout:			
Main anchorage foundations			
Tower foundations			
Windguy anchorage foundations			
Foundation Dimension:			
Main anchorage foundation			
Tower foundation			
Windguy anchorage foundation			
Cut Slope			
Slope stabilizing/protection measures	***As per GA***		
	OK	***Needs revision***	
Retaining walls			
River bank protection works			
Drainage			

Progress :

Bridge layout ☐ % completed as per design drawings

Earthwork Excavation specifications ☐ % completed and confirm to the drawings and technical

Target Completion Date as per schedule : ……..…… Delay (if any) : ……..……

Actual Completion Date : ……..…… Reason for delay : ……..……

Note:

1. *Attach Site Instruction and Inspection Report including photographs and other relevant documents*
2. *Refer instruction*

Instruction

- **Profile of bridge axis**: Check Elevations of BMs, peg A&B and profile of bridge axis to confirm the topography in General Arrangement drawing (GA), A & B peg distance and span of bridge by triangulation.

- **Bridge layout**: If topography confirms as per GA, bridge layout should be checked considering designed slope cutting, retaining structures and other slope stabilizing measures as per GA. Recommend accordingly if profile is not as per General Arrangement drawing. All pegs of layout must be kept safely till foundation is checked.

- **Foundation dimensions:** Check Cut slopes, geometrical dimensions of foundation pits, stability of cut slopes. In case the excavation not confirming to the requirements as per drawing or the Technical Specifications, the IE has to give written instruction to the contractor. Slope failures due to cut slope pitch steeper than that specified in the drawings or the Technical Specifications shall be the full responsibility of the Firm. If any discrepancy occurs between the design drawing and the actual site condition, the IE has to immediately report with suggestions to the management for amendment or rectification.

- **Slope stabilizing and protection works:** Check adequacy of protection works wherever provided. In most cases, lay out of the retaining structures given in the GA does not comply with the site condition. Therefore, IE should give the instruction for the proper lay out of the retaining structures, bank protection and drainage works as per actual site condition. The Inspection Engineer must also ensure the overall stability of slopes and the river banks.

- **Additional works:** In case any revision or rectification in the design has to be made or relocation of any or all of the foundations has to be made or the modification in stabilization/protective measures has to be made, the Inspection Engineer has to immediately report to management. Any instruction involving additional cost has to be reported to the management within 15 days and shall be effective only after approval from EMPLOYER.

Take the relevant photographs.

If the work quality is found unsatisfactory, give written instructions to the Firm for rectification, improvement or replacement.

INSPECTION FORM FOR MASONRY AND CONCRETING

Bridge No. & Name : _____	Firm's Name : _____
Firm's Site Incharge : _____	Inspection Date : _____
Date of Agreement : _____	Target Bridge Completion Date : _____

Quality :

Items to be inspected	***Conforming to the design/ specification***		***Remarks***
	Yes	***No***	
Materials :			
Sand			
Aggregates			
Block stones / boulders			
Cement			
Masonry works :			
Mortar mix			
Bond / joints			
Plumb vertical / horizontal			
Curing			
Concrete works :			
Reinforcement			
Form work			
Concrete mix			
Water cement ratio			
Compaction			
Curing			
Anchorage fitting			

Progress :

Bridge layout ☐ % completed as per design drawings

Earthwork Excavation ☐ % completed and confirm to the drawings and technical specifications

Target Completion Date as per schedule : ……..…… Delay (if any) : ……..……

Actual Completion Date : ……..…… Reason for delay : ……..……

Note:

1. *Attach Site Instruction and Inspection Report including photographs and other relevant documents*
2. *Refer instruction*

Instruction

Refer: Technical Specification Para 540, 550, 560

- **Cement:** Verify brand name with the brand name reported by the contractor. Check visually quality of cement, i.e. development of lumps, color, presence of foreign materials etc. Collect sample of cement (min. 5kg) from each sites for lab test purpose. IE will decide about testing on case to case basis. TS will make the lab test.

- **Aggregate:** Check visually content of the impurities such as clay, loam, mud, stone dust, organic materials etc. Aggregate should be free from any such impurities. Flat and flaky shaped aggregates and aggregate of unsuitable rock such as mica, marl and sand stone should be rejected. Check the grading and stocking. Aggregate should be well graded (5-10, 10-20, 20 40mm) and stocked separately according to the size. Make sieve analysis and compare the result with the specification.

- **Sand:** Check visually content of the impurities such as clay, loam, mud, organic materials etc. If, such impurities are found, recommend to wash the sand before use. Sand containing significant quantity of mica should be rejected. As far as possible coarse sand shall be collected as per specification to availability at site. Make sieve analysis and compare the result with the specification. Collect the sample of the sand (1kg) for lab testing purpose.

- **Stone:** Check visually the quality. It should be un-weathered, hard, sound and dense. Check the size. The size of stone should be 100 to 225mm for plumb concrete, 150 to 200mm for gabion works and for masonry works according to the wall thickness (ref. technical specification).

- **Tools/equipment and manpower**: Check the availability of adequate tools and equipment for the execution of the proposed work, measuring devices for ingredients mix, platform for mix preparation. Check the availability of adequate skilled labours.

- **Form Work:** Check and ensure that the form work can withstand the pressure resulting from the placement and vibration of the concrete. It should be rigid in position and sufficiently tight enough to prevent the loss of mortar during the concreting. Ensure that the form work is uniform enough to give the smooth surface to the concrete structures.

- **Masonry works.** Check the workmanship in mortar preparation i.e. dry mixing of various ingredients as per design and specification, maintaining water cement ratio and laying of the prepared mix.

  In completed masonry works, check the wall vertical to plumb, vertical joints, horizontal joints, mortar thickness, the voids inside the wall, over all finishing. Check the geometric dimensions of the works according to the design. Insure that the whole structure is cured for min. 7 days.

  In retaining structures, where hydrostatic pressure is foreseen, check the provision of sufficient weep holes.

- **Concrete works:** Check the mix preparation i.e. dry mixing of various ingredients as per design and specification. Measurement shall be in volume. Check the water cement ratio, which should not exceed 35 litters of water per 50 kg of cement. Avoid excessive use of water, which will significantly decrease the concrete strength. Slump test shall be carried out to confirm workability and water cement ratio. Slump should not exceed 80mm.

  Check the ramming of the placed concrete. Ensure that the concrete layer is placed in horizontal layers not exceeding 25cm and compacted adequately avoiding any voids.

In plumb concrete, check the minimum gap of 100mm between the adjacent boulders is fully maintained and that the boulders are not in contact with each other. And these gaps between the boulders are filled with concrete of designed mix and rammed adequately avoiding any voids. Ensure that the each layer of boulders are placed on 100mm thick concrete mats.

In Completed concrete structures, check the quality of concrete i.e., soundness, voids (honey combs) in the structure, wall vertical to plumb and line, over all finishing. Check the geometric dimensions of the structure according to the design. Insure that the whole structure is cured for min. 7 days.

- **Anchorage fitting:** Check placed anchorage parts before concreting. Give special attention to layout of anchorage parts and cable saddles. Concreting of the anchorage parts shall not be done without inspection by IE.

Take the relevant photographs.

If the work quality is found unsatisfactory, give written instructions to the Firm for rectification, improvement or replacement.

INSPECTION FORM FOR CABLE HOISTING

Bridge No. & Name : _____	Firm's Name : _____
Firm's Site Incharge : _____	Inspection Date : _____
Date of Agreement : _____	Target Bridge Completion Date : _____

Quality :

Items to be inspected	***Hoisting level of sag/camber as per GA***		***Remarks***
	Yes	***No***	
Cable hoisting			
Main cables			
Handrail cables			
Spanning cables			

Progress :

Bridge layout ☐ % completed as per design drawings

Earthwork Excavation ☐ % completed and confirm to the drawings and technical specifications

Target Completion Date as per schedule : ……..…… Delay (if any) : ……..……

Actual Completion Date : ……..…… Reason for delay : ……..……

Note:

1. *Attach Site Instruction and Inspection Report including photographs and other relevant documents*
2. *Refer instruction*

Instruction

Refer : Technical Specification para 570

- Check carefully hoisting sag/camber, cable elevations and level of cable saddles. Check the verticality of the towers (suspension bridge).

- Check and ensure proper cable terminals, i.e. thimbles number, size, spacing and appropriate fitting (grip towards the tension side of the cable), of the bulldog grips and the overlapping length at cable ends.

Take the relevant photographs .

If the work quality is found unsatisfactory, give written instructions to for rectification, improvement or replacement.

WORK COMPLETION CERTIFICATE (WCC)

Firm's Name	:	_____
Bridge No. & Name	:	_____

I .....
(Full name of Inspecting Engineer)
Certify herewith that I have duly inspected and successfully completed bridge construction and erection according to the contract condition, design drawings and technical specification.

Completion Date : ……..

Quality of Work : Good ☐ Fair ☐
Bad ☐ Unacceptable ☐

Date of Agreement	:	_____
Date to be Completed	:	_____
Date of Final Acceptance	:	_____
Delays in Months/Days	:	_____

(Time extension granted is also considered as delays)

Note:
1. *Attach filled in Forms for Final Inspection with photographs and other relevant documents. Attach additional photos of overall views for updating Central Bridge Register*
2. *Refer instruction at the back side*

Instruction

Refer: Technical Specification

After receiving the Work Completion Report (WCR) along with the Quality Assurance Document from the Firm (refer Annex III: Built in Quality Assurance), visit the site for the final inspection. Guidelines for the final inspection is detailed in the Annex I: Inspection Firm for Final Inspection. Check the followings:

- All the cables are adequately pretensioned. The free cable ends are properly protected from unwinding of cable strands.
- No nut, bolt, washer and clamp is missing and loose.
- Check the wiremesh is of required width. Wiremesh is properly stretched and fixed to both the fixation and handrail cables and suspenders with G.I. binding wires of 12 SWG @ 30cm intervals in case of suspension type bridge. Wiremesh is properly stretched and fixed to the fixation cables and suspenders with G.I. binding wires of 12 SWG @ 30cm intervals and folded around the handrail cables in case of suspended type bridge. Also check whether wiremesh is over stretched resulting narrow spacing of handrail cables at mid span in the case of suspended type bridge.
- The non-galvanized threaded steel parts are painted with coaltar.
- The suspenders are true to vertical and in proper tension.
- Towers are true to vertical (suspension type bridge).
- All windties and windguy cables are in geometry as per design, in proper tension and windties are perpendicular in plan to the bridge axis.
- Bridge is not tilted or skewed.
- The protective measures, which consists combination of proper cut/fill slopes, retaining structures, drainage works, plantation and river bank protection works are adequate and its layout and construction is as per design specification and site condition.
- **Gabion works:** Check mesh size, internal diaphragm, assembly of gabion crates, connection between crates.

  Check filling of boulders. The filling shall be of dressed boulders of proper size (150 to 200mm), placed individually by hand, bedded on all sides on each other and bonded tightly. No loose stones shall be inserted into the crate.

  Check overall layout of the gabion works and ensure that it fits to the actual site condition. Ensure that the foundation is levelled, minimum back slope of 10:1 is maintained and proper backfilling is done. Vertical joints are maintained in staggered manner. Check the geometrical dimensions of the works.
- Access to bridge is proper and functional.
- The bridge surroundings, approach trail, drains, retaining structures and any other relevant structures are properly cleaned off any dirt, surplus excavated or construction materials. The minimum clearance of all the steel parts from the ground surface has been maintained.
- And the overall appearance of the completed bridge looks aesthetically impressive.

Take the relevant photographs.

If the work quality is found unsatisfactory, shall give written instructions to the Firm for rectification, improvement or replacement. Fill in the Inspection Form for final inspection and submit it along with a copy of site instruction given to the firm and relevant photos.

If the bridge is found acceptable according to design and specifications, issue the Work Completion Certificate (WCC) along with filled in Inspection Firm for Final Inspection and relevant photographs.

INSPECTION FORM FOR MAJOR MAINTENANCE

Bridge No. & Name : _____	Firm's Name : _____
Firm's Site Incharge : _____	Inspection Date : _____
Date of Agreement : _____	Target Bridge Completion Date : _____

Quality :

Items to be inspected	***Conforming to MM Design and Specification***		***Remarks***
	Yes	***No***	
1. Pretensioning/hoisting of cables			
2. Layout/construction of bank/river Protection works			
3. Painting works :			
Primer coat (Red Lead or Red oxide zinc chromate)			
Finishing coat (polyurethane enamel paint)			
4. Replacing of missing steel parts			
5. Others completed works :			

Progress :

☐ % completed and confirm to the MM design and technical specifications

Target Completion Date as per schedule : ……..…… Delay (if any) :
……..……

Actual Completion Date : ……..…… Reason for delay :
……..……

Note:

1. *Attach Site Instruction and Inspection Report including photographs and other relevant documents*
2. *Refer instruction at the back side*

Instruction

Refer to Maintenance Design Report and Technical Specification Para 500, 600

Make first field inspection of major maintenance work during the progress of painting works of bridge parts at site. Check the following:

- Check whether the work executed is according to the maintenance design and specification.
- Ensure the painting work is done properly. Surface to be painted are thoroughly cleaned. Base coat of **red lead** or **red oxide zinc chromate primer** (red oxide primer not permitted) is applied. Finishing coat of polyurethane enamel paint is applied only after sufficient drying of base coat primer.
- Check the layout of the protective measures, which consists combination of retaining structures, drainage works, plantation and river bank protection works as per design specification and site condition.
- **Additional works**: In case any revision, addition or rectification in the maintenance design has to be made, the IE has to access and recommend for it. Such revision has to be made by the TS. Any instruction involving additional cost has to be reported to TS within 15 days and shall be effective only after approval from the management. The essential documents will be submitted by the IE along with site instruction to TS.

Take the relevant photographs.

If the work quality is found unsatisfactory, give written instructions to the Firm for rectification, improvement or replacement. Submit inspection report along with a copy of site instruction given to the firm and relevant photos.

In case of work executed with DDC collaboration, advise/suggest to the DDC site in-charge for the improvement, rectification (if any) of executed works. And also give necessary advice for execution of remaining works.

WORK COMPLETION CERTIFICATE (WCC)
(Major Maintenance)

Firm's Name	:	_____
Bridge No. & Name	:	_____

I .....
(Full name of Inspecting Engineer)
Certify herewith that I have duly inspected and successfully completed bridge construction and erection according to the contract condition, design drawings and technical specification.

Completion Date : ……..

Quality of Work : Good ☐ Fair ☐
Bad ☐ Unacceptable ☐

Date of Agreement	:	_____
Date to be Completed	:	_____
Date of Final Acceptance	:	_____
Delays in Months/Days	:	_____

(Time extension granted is also considered as delays)

Note:
1. *Attach filled in Forms for Final Inspection with photographs and other relevant documents. Attach additional photos of overall views for updating Central Bridge Register*
2. *Refer instruction at the back side*

Instruction

Refer to Maintenance Design Report and Technical Specification

After receiving the WCR along with the Quality Assurance Document from the Firm (refer Annex III of QCS: Built in Quality Assurance), visit the site for the final inspection.

Check the followings :

- Check relevant items as for New Construction.
- All the cables are adequately pretensioned. The free cable ends are properly protected from unwinding of cable strands.
- No nut, bolt, washer and clamp is missing and loose.
- Check that no steel parts are missing or damaged.
- Check the wiremesh is of required width. Wire mesh is properly stretched and fixed to both the fixation and handrail cables and suspenders with G.I. binding wires of 12 SWG @ 30cm intervals in case of suspension type bridge. Wiremesh is properly stretched and fixed to the fixation cables and suspenders with G.I. binding wires of 12 SWG @ 30cm intervals and folded around the handrail cables in case of suspended type bridge. Also check whether wiremesh is over stretched resulting narrow spacing of handrail cables at mid span in the case of suspended type bridge.
- The non-galvanized threaded steel parts are painted with coaltar.
- The suspenders are true to vertical and in proper tension.
- All windties and windguy cables are in geometry as per design, in proper tension and windties are perpendicular in plan to the bridge axis.
- Bridge is not tilted or skewed.
- The protective measures, which consists combination of proper cut/fill slopes, retaining structures, drainage works, plantation and river bank protection works are adequate and its layout and construction is as per design specification and site condition.
- Access to bridge is proper and functional.
- The bridge surroundings, approach trail, drains, retaining structures and any other relevant structures are properly cleaned off any dirt, surplus excavated or construction materials. The minimum clearance of all the steel parts from the ground surface has been maintained.
- And the overall appearance of the completed bridge looks aesthetically impressive.

Take the relevant photographs.

If there is incomplete or unacceptable works, give written instructions to the Firm and same shall be reported to the management. If the bridge is found acceptable according to design and specifications, issue the Work Completion Certificate (WCC) along with filled in Inspection Firm for Final Inspection and relevant photographs.

8.4.3 Quality Assurance

Quality Assurance (QA) is a systematic way of ensuring that the organised activities happen in a way that they were planned. Quality standards like ISO 9000 do not demand the best quality; they establish the minimum requirements to be achieved, certifying only the quality assurance system that produces the product. The QA indicates two basic things: end product being of the required quality and systematic and planned actions avoiding "crisis management".

8.4.3.1 Quality Assurance of Community Bridges

A. Work and Manning Schedule

The work schedule can be regarded as progress reporting. If the pre-planned work schedule is maintained, the supervising work can progress as planned. The Supervisor or the Quality Inspector (QI) has certain manning schedules, and if the work schedule is not followed properly, the QI or the supervisor may not reach the site on time and miss a particular stage in the construction for checking. Hence the work and manning schedule have to be properly followed to ensure quality work.

B. Work Record

In Case of Community Bridges

The Users' Committee must have a record book which is, distributed by the DDVC. It is also used for writing the minutes of the UC's meetings. The book contains orientation on construction and maintenance of community bridges. It should be used to record the committee's decisions and the work responsibilities of the committee members. It should also be used to record the financial support from the DDC, VDC, Users and others. The book should also be used for: 1) daily attendance record of the committee members involved in the construction work; 2) record of expenditures for material collections, transportation, labour wages and others; 3) writing instructions given by the technicians; 4) visitors' suggestions and remarks and 5) formation of bridge maintenance committee.

The usual practice is for one of responsible members of the UC (Site In-charge/Supervisor in other approaches) to keep a day-to-day log of all the work executed. Such logging should include mainly the type and quantity of the work completed, type and quantity of the construction materials used and the steel parts placed, etc. as per the standard format of the work record.

C. Photographic Recording

Photographic recording is very helpful in many aspects of quality assurance. Photos of the site should be taken during the following stages:

- Site assessment

  Various photos of the site as described in the survey work for a New Bridge

  Close-up views of the bridge parts, foundations and critical places for Maintenance Bridge Layout
- Completion of earth work / foundation excavation
- Material collection and foundation blocks under progress
- Placement of reinforcement and steel parts in the foundations
- Cable hoisting and sag setting
- Handing over of foreign materials and their storage
- Walkway fitting
- Final checking

8.4.3.2 Quality Assurance of Bridges Constructed

As per the principal of turnkey mode of contracting, the Firm shall assure the quality of executed work by them with the convincing evidence. The Firm has to assure that the executed works are as per prescribed Technical Specification, Norms and Design Drawings. For this, Firms shall follow the reporting and documentation procedures as detailed below.

The terms of payment shall be linked with the quality assurance. No payment to the Firm shall be made without complete Quality Assurance Document as prescribed below.

Refer: Built in Quality Assurance (Nepali version).

A. WORK AND MANNING SCHEDULES

The firm has to strictly follow the work and manning schedules proposed in the Contract Agreement. This Work Schedules shall be regarded as progress reporting by the firm and the Manning Schedules as the responsible Site Supervisor for the supervision from the Firm's side. EMPLOYER will make the field inspection and checking according to this Work Schedule. In case the Firm has to reschedule either the Work or the Manning Schedules, it has to be reproved by the EMPLOYER Management.

If the firm fails to meet the progress as per Work Schedules or the personnel supervising the construction work is different from those proposed in Manning Schedules are liable to be taken action.

If the firm fails to complete the work in time as proposed and the IE has to revisit the site for the same job, the firm has to bear the extra cost for the additional field inspection.

B. WORK RECORD

The Site Supervisor of the Firm has to keep day to day logging of all the work executed on that particular day as per actual work progress. Such logging should include mainly the type and quantity of the work completed, type and the quantity of construction materials used, anchorage parts fitted etc. as per the standard format of Work Record. The Firm shall submit the Work Reports with photographs of each item of work as prescribed in the Forms for photographic documentation in each progress reporting.

C. PHOTOGRAPHIC REPORTING

The firm shall make the photographic reporting on major part of the construction work as prescribed in the Forms for photographic documentation. The photographic reporting shall consist minimum as below:

New Construction :

- After bridge layout, showing all the foundation locations. At least one close up photograph for each of the foundations with distinct corner pegs visible in the photographs must be taken;
- After the completion of foundation excavation. At least 2 close-up photographs, one at the front and the other at the back, for each anchorage foundation. Each photograph must be taken with staff and measuring tape to confirm the dimensions of the foundation pit. The graduation on the staff/tape should easily readable from the photographs;
- Close up views of construction material stacks of rough blocks, gravel & sand separately;
- At various stages of masonry and concrete works for each foundation. Each photograph must be taken with staff held vertical and horizontal against the wall face so as to have the approximate scale of the photographs;

- Details of placement of reinforcements (close up views). The photograph should be clear enough that the number of reinforcements could be counted;
- Details of anchorage parts fitting, tower erection, cable hosting; suspender and walkway deck fitting;
- Close up view of walkway illustrating connection of walkway with main/spanning cables;
- Close up view of walkway illustrating connection of suspenders with main/handrail cables;
- Close up view of walkway illustrating fixation of the wiremesh net with suspenders, and fixation/handrail cables;
- Close up view of walkway deck (top and underneath) showing connection details;
- Close up view of connection between cross beam and windties;
- Close up view of connection between windguy and windties;
- Close up view of each anchorage blocks showing cable terminals;
- Close up view of gabion crates before filling with boulders showing mesh size (illustrated by tape), internal diaphragms, assembly of crates etc.;
- Close up view of gabion works after filling;
- Overall view of gabion protection works showing details as backfilling, dimensions and layout;
- Overall view of each foundation blocks after completion of the bridge;
- Overall views of completed bridge from right bank/left bank and upstream/down stream;
- Any other relevant feature.

Major Maintenance :

- Close up view of steel parts (walkway, suspenders, towers, all anchorage parts) after removal of old paints/rust and before new painting works;
- Close up view of steel parts (walkway, suspenders, towers, all anchorage parts) after application of red lead or red oxide zinc chromate;
- Close up view of steel parts (walkway, suspenders, towers, all anchorage parts) after application of polyutherane enamel;
- Close up view of walkway illustrating connection of walkway with main/spanning cables;
- Close up view of walkway illustrating connection of suspenders with main/handrail cables;
- Close up view of walkway illustrating fixation of the wiremesh net with suspenders, and fixation/handrail cables;
- Close up view of walkway deck (upper and underneath) showing connection details;
- Close up view of connection between cross beam and windties;
- Close up view of connection between windguy and windties;
- Close up view of each anchorage blocks showing cable terminals;
- Close up view of gabion crates before filling with boulders showing mesh size (illustrated by tape), internal diaphragms, assembly of crates etc.;
- Close up view of gabion works after filling;

- Overall view of gabion protection works showing details as backfilling, dimensions and layout;
- Overall views of completed bridge from right bank/left bank and upstream/down stream;
- Any other relevant feature.

All the photographs have to be documented in Forms for Photographic Documentation and submit to the employer each progress reporting and work completion report.

D. TEST CERTIFICATES

The Firm shall make available the test certificates of the following construction materials:

Construction Materials	Required Test
1. Cement	Setting time and Compressive Strength of 28 days
2. Steel Sections and Reinforcement Bars	Tensile, Compressive and Bending Strength
3. G.I. Wire for Gabion woks and Wiremesh	Tensile strength, Zinc coating, uniformity and adherence of zinc coating

The Firm may submit Manufacture's test certificates or test results of lab testing. The firm shall use the materials for fabrication and construction only after approval of the test certificates by Employer.

E. REPORTING

The Firm shall make progress reporting of each crucial construction stages as per work schedule. The stages of progress reporting are as listed below.

New Construction

A. After fabrication of steel parts
B. After bridge layout and excavation
C. During masonry work/concrete Work
D. After cable hoisting
E. After bridge completion

Major Maintenance

A. After fabrication of steel parts
B. During painting works
C. After work completion

The progress report shall consists test certificates, photographic documentation, work records (work logging) in prescribed formats. Then the IE shall make the field visit to verify the progress and quality and workmanship of work executed as per technical specification and design drawings. Whenever, necessary IE may visit the site according to work schedule of contract agreement even without Firm's reporting,. The IE shall give instruction to the firm in written in site instruction book for any rectification, improvement or replacement of work. For this Firm shall maintain Site Instruction Book at construction site.

F. WORK COMPLETION REPORT

After bridge completion, the Firm shall submit a Work Completion Report (WCR) with following documents:

- ◊ WCR filled in by the Firm;
- ◊ Photographic documentation;
- ◊ Weekly Work Records;
- ◊ Test Certificates.

In general, without the above documents the QCE shall not accept the Work Completion Report.

The IE shall then visit the site for final checking.