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EurolinK

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

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1 Introduction

1.1 The Project

The Messina Strait Bridge will span the Messina Strait between Calabria on the Italian mainland and the island of Sicily. The suspension bridge crossing comprises a 3,300 m main span, which will be longest in the world when constructed.

The bridge carries four marked vehicle lanes, two emergency lanes and two rail lines. The bridge superstructure comprises three separate orthotropic deck steel box girders, one for each of the Sicily and Calabria bound roadways and one for the railway. The three box girders are connected by transverse steel box cross girders spaced at 30 m. The superstructure is supported by pairs of hanger cables connected to each cross beam end. The hangers are connected to pairs of main cables on each side of the bridge (four main cables), with each main cable having a diameter of 1.24 m. The main cables are anchored at each bridge end in massive reinforced concrete anchor blocks. The main cables are supported by two steel main towers, each with a height of 399 m above mean sea level. The main towers are founded on reinforced and post-tensioned concrete footings, which are supported on underlying rock formations.

1.2 References

1.2.1 Design Specifications

1 GCG.G.02.01 rev.0. Construction of the street and railway connections: Norm for the execution of the civil work - street and railway infrastructures. Stretto di Messina, 2004 July 6.

2 GCG.G.03.04. Various works, Section 2. Stretto di Messina, 2010, July 15.

3 CG1000-P-RG-D-P-GE-00-00-00-00-00-02-A - “Design Basis, Structural, Annex,” COWI 2010

4 GCG.F.05.03 rev. 1. Technical specifications for the definitive and the executive project of the bridge - Design development requirements & guidelines. Stretto di Messina, 2004 October 22.

5 GCG.G.03.02. Technical specifications for the construction of the suspension bridge - Structural steel works and protective coatings, Stretto di Messina, 2004 July 30.

1.2.2 Codes and standards

6 EN 1990-2:2007 Basis of structural design

7 EN 1991 Eurocode 1: Actions on structures

8 EN 1993 Eurocode 3: Design of steel structures

9 Pressure Equipment Directive 97/23/EC

10 Machinery Directive 2006/42/EF

11 Low Voltage Equipment Directive 2006/95/EC

12 Electromagnetic Compability 89/336/EEC

1.2.3 Drawings

13 GC1000-P-AX-D-P-SS-R4-PA-00-00-00-01-A Gantries for tower

2 Gantries for Tower

2.1 Introduction

These performance specifications contain the requirements for the gantries, which are to be used for inspection and maintenance on the towers of the Messina Strait Bridge.

2.2 Scope of Work

The scope of work for the gantries can be summarized in the following headlines:

- Climbing gantries for the tower legs.
- Travelling gantries on the tower cross beams.

The scope of work covers detailed and workshop design, supply, installation, testing, commissioning, training of operators, as-built documentation, operation & maintenance manuals and quality assurance activities, in accordance with general requirements of the contract and this technical specification including enclosed drawings.

The design of the gantries shall include integration of the access facilities into the overall bridge design, considering interface requirements from other parts of the bridge project.

The interfaces to be considered include but are not limited to:

- Escape from and access to the gantries
- Free space passage around hoisting units in tower legs
- Free space passage of travelling base gantries on top of cross beams
- Transverse bracing and buffers between bridge girder and tower
- Passage of cross beams for the tower, hydraulic buffers and suspended deck
- Floodlight luminaires on the tower
- Utility water supply systems
- Power supply and electrical systems including lightning equipment

- Corrosion protection system
- Control and monitoring systems
- Safety and operation control/SCADA
- Communication systems.

The interfaces are described further in this report.

2.3 General Requirements

2.3.1 General

The performance specification for the gantries summarises the:

- Functional requirements
- Operational requirements
- Structural requirements
- M & E requirements
- Material requirements
- Documentation
- Codes and standards.

The bridge towers must be equipped with climbing gantries on the legs and travelling gantries including baskets on the tower cross beams as shown in drawings.

The facilities shall be designed in such a way that the following main objectives are fulfilled:

- The gantries shall be easy to erect and operate.
- All relevant safety aspects are provided for.
- The gantries do not damage the tower, in particular the surface treatment, or adjacent structures or electrical and mechanical equipment.

- The gantries are robust and have a long service lifetime.

The gantries have the following main features:

2.3.2 Climbing Gantries for the Tower Legs

Climbing gantries shall be provided for access to all external surfaces of the towers.

The climbing gantry must be a sky climber type surrounding the tower leg with removable parts to allow for passage of cross beams, hydraulic buffers and the suspended deck including the aerofoils on the windscreen. The gantry shall be erected and demounted at tower base. Fixed hoists in the tower leg at top of cross beam level shall hoist the gantry step-by-step from tower base to the upper cross beam by successively changing to the next hoist system. When the gantry is raised as much as possible by the lowest hoist system an authorized worker should let down the wires from the next hoist system. Workers on the gantry attach the safety hook on the wires to the gantry. The gantry can be raised a bit by the second hoist system to take off the tensile loading in the lowest hoist system. The lowest hoist system can be pulled back to the tower to allow for passage of the gantry.

2.3.3 Gantries on the Tower Cross Beam

Travelling gantries for external access of the tower cross beams shall be provided. One gantry on each tower cross beams i.e. 6 gantries in total.

The gantries must be provided with internal hoisted basket (2 pieces) to give access to the sides and bottom of the cross beams.

2.4 Functional Requirements

2.4.1 General

The gantries must provide access to the entire external surface of the towers and cross beams for inspection and maintenance.

The gantries in the typical drawings must give access to the following areas for inspection and maintenance:

- The entire circumference of the tower legs and cross beams
- All external structural assemblies
- All openings in tower
- All mechanical and electrical installations
- Surface cleaning and treatment of tower

The following areas will not be available for inspection from gantries:

- The tower saddle
- The tower base

2.4.2 Size of Gantries

The size of the equipment must be (approx.):

Climbing gantry (on tower legs)	L x W x H = 60 x 1.0 x 1.5 m
Hoist equipment	L x W x H = 1400x1910x950 mm
Climbing height	H = 140 m
Hoisting wires	D = 21.5 mm

Travelling gantry (on cross beams)	L x W x H = 2.0 x 11 x 25 m
Motorized gantry base with hoist	L x W x H = 4 x 2 x 4 m
Gantry rails distance	W = 1.2 m
Basket	L x W x H = 0.9 x 0.9 x 1.5 m
Hoisting wires for basket	D = 9.5 mm

2.4.3 Tower Dimensions

The main dimensions of the tower are (approx.):

• Tower leg	L x W = 20 x 12 m
• Tower height including saddle	H = 381 m
• Tower height excluding saddle	H = 366.4 m
• Cross beam	W x H = 8 x 11.5/22 m
• Cross beam length	L = 41.6 to 58.5 m
• Height between cross beams	H = 125 m

2.5 Operational Requirements

2.5.1 General

The minimum travel speed of the gantries must be:

Climbing gantries	v = 9 m/min
Travelling gantries	v = 18 m/min
Basket	v = 9 m/min

The travel speed must be valid for the climbing gantries considering an inclination of the tower legs of approx. 2º relative to vertical.

The travel speed must be valid for the travelling gantries considering an inclination of the cross beams of maximum 14º relative to horizontal.

The gantries must be designed to perform all operations in gust wind speeds 70-385 m above sea level, equivalent to a basic wind speed of:

v_b = 15 m/s (10 min. average at 10 m above sea level)

The gantries must be designed to survive a 50-year storm, when fully loaded and locked in parking position. The wind speed in this condition will be equivalent to a basic wind speed of:

29 m/s (10 min. average at 10 m above mean sea level)

The design wind speed at gantry and basket levels shall be calculated in accordance with the document no. GCG.F.04.01 "Basis of design and expected performance levels for the bridge".

2.5.2 Climbing Gantries

The gantry must be easy to erect from base of tower and shall include removable parts to allow for passage of cross beams, hydraulic buffers and the suspended deck.

The railing shall be a structural part to ensure the structural stability while passing the hydraulic buffers.

When the gantry is erected a coordinated wire system including blocks and demountable beams through sealed openings in the tower leg can be arranged for lifting the gantry.

The gantry can be operated from base of tower to top of upper cross beam by successively to hook on and release the gantry to/from the subsequent hoist.

At the top of tower saddles Professional Rope Access Technician inspection will be performed.

All gantries must be provided with handrails and rails for safety wire to the extent required by Italian Regulations.

The gantries must be horizontally stabilized by guiding electromagnetic wheels against the tower. The magnetic wheels shall only be activated in parkering / inspection & maintenance situations. When the gantry is moving the magnetism shall be turned off and the wheels shall only support and guide the gantry.

The design shall provide an optimal and safe operation without damage to any elements or the tower surface coating. Special cut-outs in the shape of the gantry shall be made for passage of the floodlight luminaires on the tower.

Easy and safe access to gantries must be provided though doors in the tower legs at top of cross beam levels.

The gantries must be operational from the gantry and/or the tower by a mobile control panel.

The climbing gantry system must be equipped with separate safety wires.

The climbing gantry shall be stored in a lockable indoor environment when not used. The gantry shall be accessible only for authorized personnel. Transportation of the gantry shall be possible by a truck with a crane.

2.5.3 Travelling Gantries

The gantry must be supported by a base frame which is travelling on rails mounted on top of the cross beam. The gantry base must be equipped with a motorized drive and hoist for lifting basket and miscellaneous equipment.

The gantry truss must be hanging on the gantry base and will include the sides and bottom of the cross beam.

The sides of the cross beam are accessed by basket hoisted inside the vertical gantry truss. The basket also gives access to the gantry platform below the cross beam between the vertical gantry trusses.

The travelling gantry is self-aligning in the horizontal and transverse direction. In transverse direction the gantry will be self-aligned and guided by flanged wheels on rails and by the horizontal guide system. The vertical truss should be hinged to the base frame.

The gantry for the cross beam must be able to travel the entire length of the cross beam between the tower legs. The gantry on the upper cross beam shall be able to pass the enclosed stairway to the saddle.

The vertical gantry truss can be supported by horizontal guide beams with magnetic wheels for damping of the movements of the gantry. The horizontal guide system shall include a stiff spring and it shall only be possible to activate the magnetic wheels (electromagnetic) in a parking / inspection & maintenance situation.

The gantry rail and guide beams must be replaceable.

The gantry base shall provide free access profile to pass on the cross beam during operation and in case of emergency.

Each basket shall be propelled by its own hoist.

When not in use the vertical gantry truss and the platform shall be demounted and stored inside the tower. The gantry base shall be parked and stored under a cover.

2.5.4 Clearances

The minimum clearances between gantries and structures must be:

Tower leg	c = 0.2 m
M&E equipment	c = 0.1 m
Cross beam	c = 0.3 m
Suspended deck	c = 0.3 m
Buffers	c = 0.3 m

2.5.5 Safety

TRAVEL CONTROL

The climbing gantries shall be guided and horizontally stabilized by magnetic wheels.

In order to limit the displacements of the gantries during travelling, additional magnetic guide wheels to the side of the cross beams must be provided, as shown on drawings.

The climbing gantry and the wires shall be proof against a failure of one wire.

Provisions to prevent the gantries from running into any part of the towers must be included in the design (sensors, signalling to stop the gantries or similar).

Operators shall be trained on safe working conditions according to Operation and Maintenance instruction.

PARKING

Special support fixtures for stabilizing the gantries to the tower structure in wind conditions above maximum operation wind speed must be specified in the design and in the O & M Manual.

Parking/blocking points shall be provided at regular and frequent intervals.

Gantries must be designed for parking on the tower legs and beams with full load and 50-year wind load.

ESCAPE

In case of failure in the electrical installations or the motor drive, manual lifting to nearest escape route at doors in tower legs or top of the cross beam shall be possible.

SERVICE LIFETIME

The gantries must be robust and have a service lifetime of minimum 20 years.

2.6 Structural Requirements

2.6.1 Global Design of Travelling Gantries

The structural base frame of the travelling gantries must be designed to travel on two pairs of supporting rails as shown on drawings.

The two pairs of supporting rails must be placed at distances to optimize the structural frames and minimizing the loading on the rails.

The design of each pair of the supporting rails shall be based on the following load limitations for the gantries:

Loads [kN]	**Dead load**	**Live load**
Gantry, operation	128	12
Gantry, parked	128	10

For the establishment of reactions on one pair of the supporting rails, the variable live load for global design will be assumed acting anywhere on the entire workspace of the gantry. It is assumed that the dead load will be spread over at least 4 wheels on one pair of rails.

The nominal reactions will include any dynamic effects from generation of the gantry, basket or wind.

The reactions of the supporting rails must be based on the load combinations in accordance with document number GCG.F.04.01.

The supporting rails must be designed for 1.5 times the maximum design reaction of the gantry and basket.

Wind load, thermal induced forces and seismic loading due to earthquake shall be considered in accordance with document number GCG.F.04.01 and are not included in the loads above.

2.6.2 Local Design of Gantries and Basket

1 Permanent load (approx.)

1.1	Climbing gantry	80	kN
1.2	Basket	1	kN

1.3	Travelling gantry	128	kN

2 Variable live loads (approx.)

2.1	Personnel (manning 4)	4	kN
2.2	Painting equipment	2	kN
2.3	Watertank on climbing gantry	15	kN
2.4	Mobile hoist & wires	3	kN
2.5	Concentrated load on 0.1x0.1 m	1	kN
2.6	Climbing speed	9	m/min.
2.7	Travelling speed	18	m/min.
2.8	Basket speed	9	m/min.

3 Variable environmental loads (approx.)

3.1	Operation wind speed	20	m/s
3.2	Parked gantry wind speed	50	m/s
3.3	Seismic load	≤ 6.3	m/s^2
3.4	Thermal load	-2/43	ºC

All handrails must be designed for a variable horizontal load along the upper rail of:

p = 1.0 kN/m

The height of the handrail must be a minimum of 1.5 m.

2.7 Mechanical & Electrical Requirements

2.7.1 General

The scope of work for mechanical and electrical works in relation to the climbing gantries, travelling gantries and baskets can be stated as follows in headlines:

- **Climbing gantries (4 pieces)**
  - Base gantry with removable parts
  - Fixed hoist units in tower leg at top of cross beam level
  - Hoisting wire system
  - Magnetic stabilizing wheels
  - Power supply
  - Glass fibre reinforced plastic watertank and high-pressure cleaner
  - Fire extinguishing system
  - Control & monitoring
  - Safety & operation controls
  - Communication.
- **Travelling gantries (6 pieces)**
  - Gantry supporting base frame
  - Trolley equipment
  - Gantry truss structure

- Supporting rails
- Guide beams with magnetic wheels
- Wind screen panels
- Electrical powered drive system
- Electrodynamic motor brake for normal braking
- Electromagnetic disc brake for parking and emergency situations, equipped with deadman's lock
- Mechanical hand brake
- Fire extinguishing system
- Power supply
- Electrical & instrumentation systems
- Control & monitoring
- Safety & operation controls
- Communication.

• **Hanger Baskets (6 pieces)**

- Base basket
- Lifting wire system
- Stationary or mobile hoist
- Power supply
- Control & monitoring
- Safety & operation controls
- Communication.

2.7.2 Power Supply

• **Power supply to gantries**

- The lifting hoists for the climbing gantry shall be supplied from the power installation in the tower.
- The driving unit for the travelling gantries and the hoist for the basket shall be connected to the power installation in the tower by flexible cords or by busbar.

• **Diesel generators**

- A diesel generator shall be provided for the climbing gantry as power supply for hand tools, luminaries and if necessary for towing an escape rope.

2.7.3 Lighting equipment

- Illumination for the working area itself shall be provided. The luminaries shall be provided with built in batteries with a capacity of minimum one hour backup time.
- The luminaries shall be manufactured in such a way that it is easy to replace lamps or tubes with new ones, only by using hand tools.
- Lamps or tubes shall be of a type with a long lifetime and the ballasts in the luminaries shall be electronics.
- An average illumination level of minimum 200 lx shall be provided at the working area. The uniformity (E minimum/E average) shall be ≥ 30%.
- The luminaries must not dazzle the road-users or the ships.

2.8 Materials

2.8.1 General

Materials, components and equipment must be of recognised and well-known make and available in Italy as standard components.

Gantries for the towers will be fabricated from Grade S355J2+N structural steels, produced in accordance with EN 10025-4. Mechanical components will be fabricated from Grade 316L (W.Nr.1.4404), produced in accordance with EN10088. All material shall be delievered with 3.1 inspection certificate according to EN 10204.

Replacement of installations and equipment with short service life must be easy. Components to be regularly inspected and maintained must be easily accessible and removable.

All materials must be selected with due regard to service in sea-water environment for the specified service lifetime of 25 years. Importance must be attached to selection of lightweight materials with a minimum of maintenance requirements during the service life.

Minimising the reactions on supporting cables and hangers must be given high priority in the choice of materials in order to optimise the cables and support arrangement.

2.8.2 Corrosion Protection

The surface treatment of the gantry carbon steel structure, painting and stainless steel shall meet the requirements of atmospheric corrosivity category C5-M according to EN 12944. Hot dip galvanizing coating of 140 µm shall be applied acc. to EN 1461.

The gantries must be painted to match the tower.

All gantry parts must be made of galvanized carbon steel or stainless steel with the aim to sustain the environmental conditions present in the Strait of Messina, without further maintenance for a period of minimum 25 years. Due attention must be paid to the effects of mechanical wear, grease or other liquids, on inside as well as outside surfaces.

Due attention must be paid to the problem of galvanic corrosion by electric isolation, as required, between different materials.

Due attention must be paid to the steel composition in relation to hot dip galvanising (silicon content).

Attention must be paid to the corrosive environment, corrosion category C5-M according to EN 12944, when selecting materials and components.

The specific requirements to pre-treatment and to corrosion protection systems must be specified in the detailed design of the gantries.

2.9 Codes and Standards

The design of the gantries and the installations on the gantries with regard to safety, materials, and loads will follow relevant Italian and European Norms (EN) and regulations.