Concessionaria per la progettazione, realizzazione e gestione del collegamento stabile tra la Sicilia e il Continente Organismo di Diritto Pubblico
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PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.

IMPREGILO S.p.A. (MANDATARIA)
SOCIETÀ ITALIANA PER CONDOTTE D'ACQUA S.p.A. (MANDANTE)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. DI RAVENNA SOC. COOP. A.R.L. (MANDANTE)
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A.C.I. S.C.P.A. - CONSORZIO STABILE (MANDANTE)

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Unità Funzionale	OPERA DI ATTRAVERSAMENTO	PI0007_F0
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INDICE

Abbreviations

AC	Alternating Current - corrente alternata
AID	Automatic Incident Detection - sistema di identificazione automatica
ALPR	Automatic Licence Plate Recognition (Targa di riconoscimento automatico)
ANSI	American National Standards Institute (istituto nazionale americano per gli standard)
ASTM	American Society for Testing and Materials
AVC	Automatic Vehicle Classification (classificazione automatica del veicolo)
BAN	Bridge Area Network
Bridge	Messina Strait Bridge
BS	British Standard
CCD	Charged Coupled Device
CCITT	*Comité Consultatif International Téléphonique et Télégraphique*(4) , livello mondiale
CCTV	Closed Circuit TeleVision-(televisione/telecamera a circuito chiuso)
CEI	Comitato Elettrotecnico Italiano
CEN	*Comité Européen de Normalisation*, livello europeo
CMS	Control and Monitoring System
CSP	Computing, Simulation & Prediction
dB	deciBel
dBi	Gain relative to isotropic antenna
dBm	Power level relative to 1 mW
DC	Direct Current - corrente continua
EBB	Equipotential Bonding Bar -Barra equipotenziale
EMC	ElectroMagnetic Compatibility-Compabilità elettromagnetica
EN	Europa Norm
ENEL	Italian Electrical Power Utility
ETSI	Europeam Telecommunications Standard Institute

GBIC	Gigabit Interface Converter
General Contractor	Eurolink
HMI	Human-Machine-Interface
HV	High Voltage
IR	Infra Rossi
IEC	International Electrical Commission
IMS	Incident Management System
kA	kilo Ampere
kV	kilo Volt
LAN	Local Area Network - (rete ad estensione locale)
LCC	Life Cycle Cost
LCS	Roadway Lane Control Signals (Lanterne semaforiche veicolari di corsia).
LPL	Lightning Protection Level-Livello di protezione
LPS	Lightning Protection System - Sistema di protezione contro i fulmini
LPZ	Lightining Protection Zone - Zona di protezione da fulminazione
LV (BT)	Low Voltage (Bassa Tensione in c.a. (400/230V))
MDIX	Medium Dependent Interface
M&E	Mechanical and Electrical
MMI	Man Machine Interface
NIC	Network Interface Controller
PBX	Private Branche eXchange
PDS	Premises Distribution System
PE	Protective Earthing - Conduttore di protezione
PEN	Conduttore di protezione e neutro
PMS	Power Management System - Sistema di gestione del la potenza
PSTN	Public Switched Telephone Network-(rete telefonica commutata ad accesso pubblico)
RFI	The Italian Railroad authority "Rete Ferroviaria Italiana"
RTMS	Road Traffic Management System (sistema di gestione del traffico stradale)

RWiM	Railroad Weight In Motion system (sistema per il rilevamento dinamico del peso). In this document RWiM is solely referring to Weight In Motion systems for trains. See also WiM.
SCADA	Supervisory Control and Data Acquisition system- Sistemi di Supervisione Controllo ed Acquisizione Dati
SHMS	Structural Health Monitoring System
SI	System of Units
SILS	Serviceability level of the Bridge: Extreme accidental and environmental loading conditions
SLS 1 and 2	Serviceability level of the Bridge (Normal use)
SPD	Surge Protection Device
TCS	Traffic Control System (sistema di controllo del traffico)
TETRA	TErrestrial Trunked Radio-(radio multiaccesso transeuropea)
UNI	Ente Nazionale Italiano di Unificazione
UPS	Uninterruptible Power Supply - alimentazione continua
VLAN	Virtual Local Area Network
VMS	Variable Message Sign (pannello a messaggio variabile)
VoIP	Voice Over internet Protocol
WAN	Wide Area Network-(rete a grande copertura geografica)
WiM	Weight In Motion system (sistema per il rilevamento dinamico del peso). In this document WiM is solely referring to roadway WiM. See also RWiM.

1 Introduction

This document describes the Mechanical and Electrical (M&E) Works to be performed under the contract component no. 28 (CdP 28).

The M&E design work covers the main bridge between eastern viaduct bridge and western viaduct bridge. The bridge has a dual carriageway road with two lanes and an emergency lane in each direction and a dual railway track in the middle section of the bridge.

The railway installations and all M&E installations outside the Main Bridge and anchor blocks are not covered by this document.

2 Introduction

2.1 Stretto di Messina Link

The characteristics and overall scope of the Permanent Works under CdP 28 of the Contract are outlined as follows:

- The limits for M&E design works included in this document covers main bridge only and are limited to the part of the bridge between the eastern viaduct bridge and western viaduct bridge, but covers anchor blocks also.
- A dual carriageway road on the bridge with two lanes in each direction and service road lanes.
- A dual railway track in the middle section of the bridge (except technical railway installations).

Furthermore, the M&E bridge design cover preparations for these parts of the installations which will be installed outside the Main Bridge but are natural part of the bridge installations. These parts of the bridge installations are:

- Main power supply substations on shore in Calabria and Messina
- Water pumping station
- Control Room for operation and management of the Bridge
- Structural measurement sensors to be installed outside the Bridge area

The design of M&E systems outside the Main Bridge and anchorage blocks are covered by separate design package prepared by the General Contractor under CdP 10, 12, 18, 19 and 45.

These Design Specifications for CdP 28 are based on the contractual documents issued by Stretto di Messina S.p.A particularly GCG.F.05.03 Requisiti e linee guida per lo sviluppo della Progettazione and GCG.G.03.05 Impianti elettrici, meccanici e speciali.

The design documents consist of a number documents which together define and present the design of the Impianti elettrici, meccanici e speciali as required in the Contract for the Definitovo Stage.

The following documents for CdP 28 are included in the Definitivo Stage of the Works and as requested by the Italian Law:

1. Ralazione Descriptiva – Description Report (this report)
2. Relazione Tecnica – Technical Report
    - Codice: CG1000-P-2S-D-P-IT-M4-C3-00-00-00-02 General Specifications – Mechanical and Electrical
    - Codice: CG1000-P-1R-D-P-IT-M4-GC-00-00-00-01 Calculation report
    - Codice: CG1000-P-4R-D-P-IT-E2-SI-00-00-00-01 Calculation report – Lighting
    - Codice: CG1000-P-2S-D-P-IT-M3-SM-00-00-00-01 Design Report-SHMS
    - Codice: CG1000-P-2S-D-P-IT-M4-C3-00-00-00-01_Management and Control
3. Technical Drawings, in accordance with document list

3 Scope of works

The following Electromechanical Installations are foreseen for this project:

- Electrical substation for normal and emergency demand
- Primary and secondary electrical network
- Distribution Switchgears and UPS system
- External Lighting (Road, Architectural, Air and Sea traffic Safety lighting system)

- Internal lighting and power distribution system
- Traffic managements system for roads
- Dehumidification System for internal volumes
- Dehumidification System for Cables
- Water distribution system (fire fighting and washing system)
- Drainage (Rain water and contaminants evacuation system)
- Elevators
- Facilities and Machineries for Operation and Maintenance
- Telephones and Communication System
- SOS System
- CCTV and Anti-intrusion System
- Monitoring system

4 General Criteria for the Design

The Environmental and Loads Conditions, as well as other obligatory design criteria which are considered during the design are those specified in the document GCG.F.04.01 " Design Basis and Performances required for the Bridge – section 10.9.4" and more detailed described in the document CG1000-P-2S-D-P-IT-M4-C3-00 00 00 02 General Specifications – Mechanical and Electrical.

All the components are designed in order to facilitate the inspection and mounting/dismounting operations for maintenance and repairing/replacement purposes.

The components are designed to avoid or reduce the risk of liquid contamination during the dismounting or in general disassembly activities. The electrical power transformers will be dry-type transformers and electrical circuit breakers will be either air insulated or vacuum insulated in order to provide environmentally neutral solutions.

The Bridge lighting system is designed in order to minimise the sea lighting impact. This is achieved by LED lighting equipment, proper shielding and system layout. The lighting design is more detailed described in the document CG1000-P-4R-D-P-IT-SI-00-00-00-01Calculation report - Lighting.

5 Description of the Plants

5.1 Power Supply and Distribution

5.1.1 System configuration

As informed in the document GCG.F.05.03 Engineering - Definitive Planning sub-section 10.9 Technological Systems (10.9.5.1.1 Power Supply and Distribution), the power connection shall be provided through a M.V. Substation (20 kV). The connection to the National Authority (ENEL) shall be done by using a dedicated double cable and shall not withstand to any other connection. The present design is based on double connection to ENELs 20kV substations in respectively Calabria and Sicilia.

The redundancy of the power supply system is provided, in order to guarantee the continuity of the performance even i case of mains failure in either Calabria substation or Sicilia substation. The system is designed to operate with power supply from only one 20 kV substation and will automatically switch over to healthy ENEL substation.

The redundancy of the lower level MV distribution system is guaranteed by construction of a ring configured distribution system, which can operate in both directions and is able to isolate faulty cable section or faulty MV substation.

The following redundancy is provided, as requested in the document GCG.F.05.03:

- the QMT-SS is redundant to QMT-SS Calabria and viceversa
- the TR , Calabria side are able to support all the load while the TR of Sicily side will be redundant system, and viceversa.
- The Power distribution on the Bridge, will be realized with a ring cable to satisfy the following three scenarios, at full simultaneous load :
    - Feeding n°1 TR Sicily side , 20/6,6 kV(6kV)
    - Feeding n°2 TR Calabria side , 20/6,6 kV(6kV)
    - Feeding n°3 (emergency) from 2 generators, 6,6 kV (6kV) in parallel on the ring cable

- The Power Center of each 6kV/0,4 kV substation is redundant with the Power Center of the subsequent 6/0,4 kV substation.

The lower medium voltage level is defined as 6 kV as suggested in the document GCG.F.05.03 (sub-section 10.9.5.1.1 Power Supply and Distribution). The voltage level of 6kV can be operated between 6 and 7.2 kV and is one of the IEC standardised voltages for medium voltage distribution of electrical power supply. All major manufacturers offer equipment designed for 7.2kV voltage level and this voltage is preferred due to compactness of switchgears, transformers as well more economical solutions for smaller power distribution systems with power demand lower than 5 MVA.

Furthermore, the equipment for 12 kV and 24 kV is mainly manufactured for rather high currents e.g. circuit breakers are designed for minimum 630A at 24 kV level, which is corresponding to more than 20 MVA for a single feeder at 20 kV operation voltage.

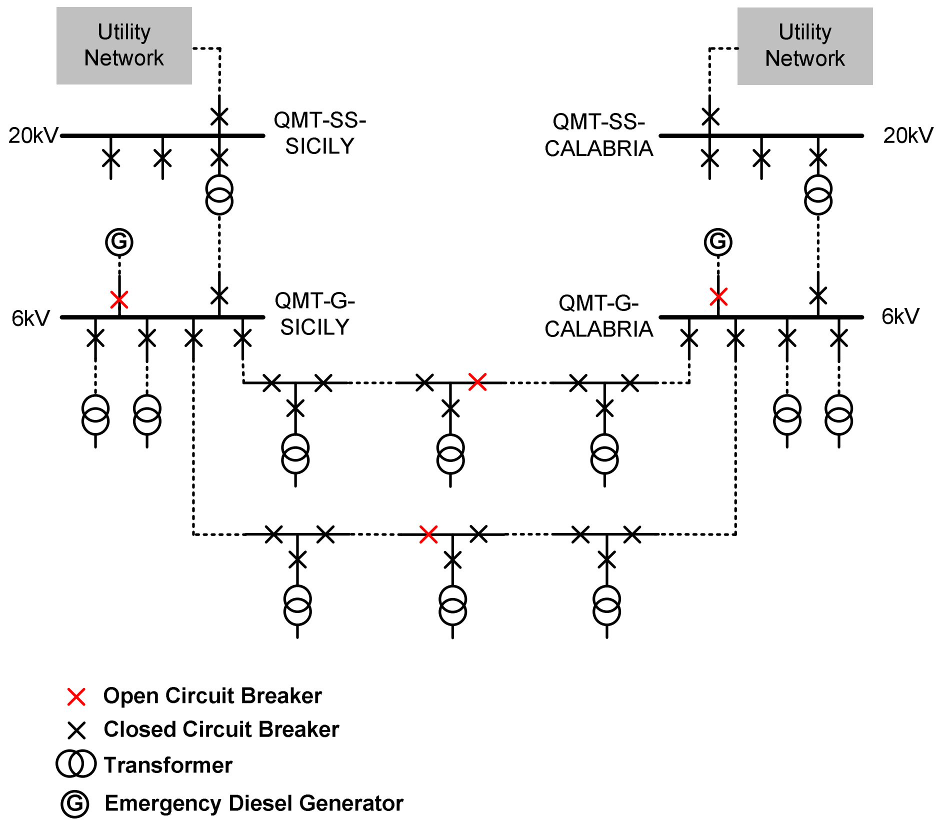


Fig. 5.1 Power distribution system topologi

5.1.2 Load classification and demand

The estimated power demand for the M&E installations on bridges is:

- Power demand during daylight hours: approx. 5.0 MW
- Power demand during night hours: approx. 5.4 MW

Detail of the electrical load analysis are presented in the Electrical Calculation Report CG1000 P 4R D P IT E2 SI 00 00 00 01 , sub-section 2.3..

The electrical loads, are classified as follows:

a) Critical loads with centralized UPS system
- Control Room equipment
- Monitoring and supervision instruments
- Sea and air traffic lights
- VS panels (Variable Signal Panels)
- Telephone and data transmission
- Security/safety related lamps e.g. at access control facilities
- Exit signs

b) Critical loads with independent units of emergency
- Anti-intrusion, alarms and cameras

c) Loads under emergency generators feeding
- Elevators
- UPS
- Road Lighting
- Internal lighting and maintenance routes lighting.

d) Normal loads connected to the automatic transfer switchgear (with possibility of disconnection in case of ENEL failure)
- Power sockets
- Dehumidification system

e) Normal loads connected to switchgears without automatic Transfer.
- Architectural lighting and catenaries

- The essential loads to be supplied from emergency power supply are estimated to be approx. 1.5 MW during night load conditions.
- The critical essential loads to be supplied from an uninterruptible power supply are estimated to be approx. 0.32 MW (ref. Electrical Calculation Report CG1000 P 4R D P IT E2 SI 00 00 00 01, sub-section 2.3.1).

5.2 Emergency power supply

5.2.1 System configuration

The emergency power supply is necessary for power supply of the mechanical and electrical systems in case of fatal failure in both parts of the national grid in respectively Calabria and Sicilia. In such case it is not necessary to operate all systems, but it is necessary to keep operation of essential systems which are important for safety of the bridge users and supervision of the bridge operation.

These essential systems will be supplied from an emergency generator with diesel powered engine. There will be one emergency generator set connected to each of the main power substations in Calabria and Sicilia.

Loads which shall not be exposed to power interruption, critical essential loads will be supplied fro centralized uninterruptible power supply (UPS) units equipped with batteries.

5.2.2 Emergency generators

The diesel generators will start automatically in case of loss of voltage in the ENEL grid. The operation of the switching on to the bridge power supply will be controlled either manually by an operator in the control room or automatically by a computer based Power Management system (PMS). The diesel generators are able to take over the power supply within 20-30 seconds.


The estimated power demand for emergency power supply is 1.5MW The calculation of the power demand is presented in document CG1000-P-1R-D-P-IT-M4-GC-00 00 00 01 Calculation Report.

The diesel generators will be either designed for direct operation at 6 kV level or equipped with step up transformer and designed for operation with 400/230 V generator. In this phase of the project the emergency diesel generators are chosen to operate generator with nominal voltage 7.2kV and operation voltage 6.0kV, as suggested in GCG.F.05.03 Requisiti e linee guida per lo sviluppo della Progettazione. The final choice of the generation level may be 400 V and will be decided during projetto essecutivo phase in cooperation with the Owner.

5.2.3 Battery powered uninterruptible power supply

In order to protect the critical essential systems against loss of power supply these systems will be connected to battery based uninterruptible power supply (UPS) units rated for 30minutes to 3 hours continuous power supply to these critical essential systems. The critical essential systems are security systems including access control, SCADA and mechanical and electrical system control and monitoring, CCTV monitoring, telecommunication system, data transmission network, variable message signs etc. The UPS units will provide possibility for programming of the times for battery based power supply to each of the critical systems and it will be possible to reprograme of these times as decided by the operation staff. The UPS units are defined as single phase units (1x230V - bipolar, 50Hz) in order to have slim design of these units to be installed at the substations on the bridge deck and with very limited space for the entire substation. The final design and choose between 3-phase and single phase solution will be decided during the projetto essecutivo phase.

5.2.4 Redundancy in configuration of the power supply

Road lighting installations which are essential for operation of the bridge, but are not critical for the use of the bridge are designed as redundant for each second road light. This means that in case of fatal failure in one transformer substation on the bridge deck only each second lighting mast will loose power supply. This is achieved due to configuration of the power supply to each second road lighting mast from the same transformer substation. Therefore each section of road lighting is supplied from two transformer substations. This principle is explained on drawing CG1000-P3ADPIT-E2SI000000 Illuminazione sterna – Fornitura e principi di controllo.

Operation of all loads on the bridge is designed as always supported by a redundant power supply from at least two ENEL power supply points. In case of a power failure in one of the ENEL substations the loads will loose power supply for few seconds only and the system will be automatically reconfigured to supply from the healthy substation.

The essential loads and critical essential loads will be further backed up by emergency power supply either fro diesel generator unit or for critical loads also supported by battery based UPS.

5.2.5 MV power distribution

The medium voltage distribution system will be based on on substations installed in climatized housings mounted along the bridge deck between railway area and the roadway area and in the bridge towers.

The substation housings will be divided in separate compartments for each type of equipment:

- MV switchgear compartment
- Transformer compartment
- Low-voltage switchgear compartment
- Communications compartment
- Fire fighting equipment and air-conditioning compartment
- Control and monitoring compartment

The substation housings and its compartments will be equipped with fire detection and automatic fire fighting equipment.

The power distribution will be based on fire retardant copper cables run in cable ladders inside the bridge girder. The ring cables will be separated and one part of ring cable will be installed in the northern girder and the second part will be installed in the southern girder.

The cable ladders will be made of fire retardant and corrosion free fibre glass.

The switchboards of the main substations, QMT-SS and QMT-G will be provided with withdrawable type switchgear. The main substations will be located in separate substation buildings, equipped with all necessary supporting and safety installations, including ventilation, fire detection, automatic fire fighting, lighting etc. These buildings are covered by a separate design package.

The switchgears will be metal-enclosed switchgear for indoor installation. The switchgears will be as manufacturer Schneider SM6, ABB Unigear, or similar. These switchgear will be constructed for 24kV, 50Hz and short time withstand current 31.5 kA (1s), or 20kA (1s), which will be decided in the Projetto esecutivo phase. The switchgear insulation level will be 125 kV (for kV peak 1.2/50 μs).

Fig. 5.2.5 Example of MV switchgear constructions

The switchboards on the bridge and in the towers will be fixed circuit breaker type switchboards, as Schneider SM6, ABB Safeplus, or similar. This switchgear will be constructed for 7.2kV, 50Hz and short time withstand current not less than 16 kA (1s). The switchgear insulation level will be 60 kV (kV peak at 1.2/50 μs).

The specification details of the MV distribution system is further detailed in the document CG1000-P-2S-D-P-IT-M4-C3-00 00 00 02 General Specifications – Mechanical and Electrical.

All the switchgear will be provided with electronic control units for relay protection and remote control and monitoring. The switchgear automation system will be incorporated into the power management system (PMS) in the control room. This PMS system will be a tool for automatic or manual control of the entire medium voltage distribution system.

5.2.6 Low-voltage power distribution

The low voltage distribution to the electrically operated mechanical systems and electrical systems on the bridge will be carried out by means of electrical cables supplied from low voltage switchboards.

All the low voltage switchboards will be metal enclosed switchgear located as shown on the drawings. Majority of the low voltage switchboards will be installed in connection with local substations on the bridge deck, in the bridge tower substations and main substations located in the substation buildings.

The low voltage switchboards will be equipped with fixed type of switchgear. The switchboards will be constructed for. It will comply with the following requirements:

- Rated operating voltage U_e = 400 V, 3ph+N+PE
- Rated insulation voltage U_r = 690 V
- Rated impulse voltage strength U_{imp} 6 kV
- short circuit withstand current 20 kA (1s)
- Overvoltage category III
- Rated frequency 50 Hz
- Degree of protection IP43, if nothing else indicated on the drawings
- Type tested in accordance to IEC 61 641-1, IEC 60 439-1, CEI 439-1

The calculated short circuit currents on the low-voltage side of the transformers in the whole distribution system are below 10 kA, as presented in the document CG1000-P-1R-D-P-IT-M4-GC-00 00 00 01 Calculation report, section 2.7.1.

The power distribution will be based on fire retardant copper cables run in cable ladders inside the bridge girder. The low-voltage cables will be with XLPE insulation and copper conductors. These cables will have the following characteristics:

- Rated voltage level: ≥690V
- Conductor type: stranded copper
- Manufacturing and test standard: IEC 60512
- Fire resistance: fire retardant

The cable installation when passing bridge birder sections between two power supply areas (approximately for each 500 m of bridge girder length) and passing through bridge deck will be carried out through fire barriers constructed by means of MCT transits as MCT Brattberg, or similar.

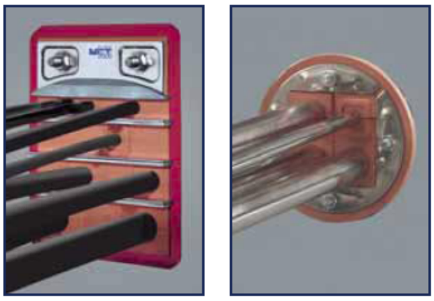


Fig. 5.2 Example of cable transits

5.3 External Lighting (Road, Architectural)

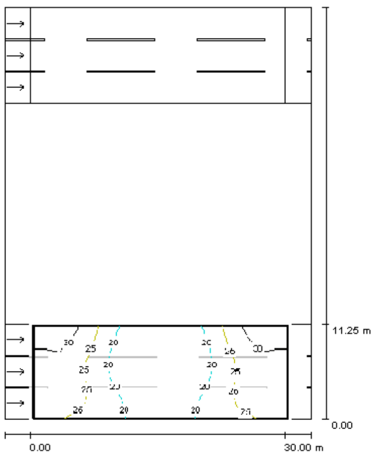
The following lighting installations will be established on the bridge.

- Road lighting (including service roads)
- Architectural lighting for Towers and Suspension System, including Deck
- Navigation and aircraft warning lights

The road lighting is designed with use of LED technology to minimise power consumption and spill light, and to facilitate maintenance.

The lighting design and calculations are presented in the document CG1000-P-1R-D-P-IT-M4-GC-00 00 00 01 Calculation Report.

Messina / Road 1 / Results overview



Maintenance factor: 0.80

Grid: 10 x 9 Points
Accompanying Street Elements: Road 1.
tarmac: C2, q0: 0.070
Selected Lighting Class: ME2

(All lighting performance requirements are met.)

	L_{av} [cd/m²]	U0	Ul	TI [%]	SR
Calculated values:	1.5	0.6	0.8	10	0.8
Required values according to class:	≥ 1.5	≥ 0.4	≥ 0.7	≤ 10	≥ 0.5
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓

Assigned viewer (3 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]
1	Betragter 1	(-60.000, 1.875, 1.500)	1.6	0.6	0.8	6
2	Betragter 2	(-60.000, 5.625, 1.500)	1.6	0.6	0.8	8
3	Betragter 3	(-60.000, 9.375, 1.500)	1.5	0.6	0.9	10

The technical specifications for the lighting equipment are given in the document CG1000-P-2S-D-P-IT-M4-C3-00 00 00 02 General Specifications – Mechanical and Electrical.

5.4 Sea traffic safety lighting system

The sea traffic marking system of the Bridge is designed in accordance with IALA recommendations and will be finally designed as agreed with the Marine Authority (i.e. COMANDO ZONA FARI – "MARIFARI MESSINA").

The bridge will not restrict the navigable water for any vessels with a height below the level of the bridge deck underside. The leading lights are placed in accordance with the navigation channels defined for the Messina Strait in 2008. These navigation channels may be modified by the naval authorities in accordance with the characteristics of the bridge. The navigation lights shall then be moved accordingly.

Red and green leading lights, and white range lights will equipped with long-life, LED lamps.

The effective range of the lights will be 7.5 - 10 nm.

All lighting equipment will be supplied by uninterruptible power supply system (UPS).

The operation will be monitored by current sensors, and will be signalled to the CMS/SCADA system.

Status of lights for navigational marking will be indicated on the CMS operator panel and SCADA large screen wall in the Control Room in the Centro Direzionale. In case of any lamp failure or loss of function the system operators will be warned and will be able to initiate proper actions.

5.5 Air traffic Safety lighting system

Obstacle lights are designed according to the ICAO, International Civil Aviation Organization, (Annex 14 – Volume 1° - chapter 4°) and "Regulation for the airport construction and operation"- ENAC, OAC, NIKAO standards.

White, flashing aviation warning lights, high intensity type A, will be located from the ground level to the top of the towers and at approximately 100 m spacing. Each light has a maximum spread of

120˚. Therefore, to ensure visibility from all bearings 4 lights will be placed at each level. The lights will be mounted in openings in the tower walls, to allow maintenance from the inside and to avoid that the luminaires create shadows in the architectural illumination of the tower surfaces.

The intensity of the light emission, is automatically adjustable by photocell / CMS/SCADA in three steps, corresponding to full daylight (200,000 cd), twilight (20,000 cd), and night (2,000 cd). The high intensity obstacle lights are equipped with xenon lamps.

The feeding of the mentioned switchgears will be continuous from UPS and with diesel genset backup and the UPS will have at least 1.0 hour back-up time.

Aeronautical marking of the cable stays will be medium intensity fixed red lights as ICAO type C, equipped with LED lamps.

Status of lights for aeronautical marking will be indicated on the CMS operator panel and SCADA large screen wall in the Control Room in the Centro Direzionale. In case of any lamp failure or loss of function the system operators will be warned and will be able to initiate proper actions.

5.6 Internal lighting

Lighting will be installed in the internal volumes (bridge deck, towers, crossing beams, anchor blocks etc.) to allow operation, inspection and maintenance activities.

All the technical rooms and access routes to these rooms will be provided with internal lighting and exit signs.

All access facilities will be provided with lighting.

All interior light will be LED-tubes, that reduce the power consumption and have a long life time and less maintenance, than standard incandescent or fluorescent lamps.

The installations include interior lighting and power in all parts of the bridge that are accessible for inspections, maintenance or service.

An average illumination level of minimum 200 lx will be provided at all areas where regular work, maintenance or operation takes place. The uniformity (E minimum/E average) will be ≥ 30 %.

An average illumination level of minimum 50 lx will be provided along walkways. The uniformity (E minimum/E average) will be ≥ 30 %.

Emergency lighting along access ways / escape routes, as well as at working area will be provided.

The emergency lighting will provide minimum 5 lx. The uniformity (E minimum/E average) will be ≥ 5 %.

Luminaires will be manufactured in such a way that it is easy to replace lamps by using common hand tools.

Every third of the internal luminaires will be equipped for emergency lighting and will be supplied from UPS which have a capacity at minimum one hour back up time.

The emergency lighting will switch on automatically when the power supply to general lighting circuit is off for any reason.

The luminaires will have reinforced non-flammable polyester body and be able to function at an ambient temperature of 55 degrees Celsius. The IP code will be 65 and the security class will be II (double insulated). The vandal class will be Class II.

5.7 Socket outlets for maintenance

All the maintenance and inspection routes will be provided with power sockets (at intervals of 30 meters) for tools or auxiliary lamps connection.

All socket outlets will have a screwed-on cover to the outlet, providing a degree of protection min. IP 56, and be impact proof.

Socket outlets (except where one single outlet is required) will be placed in clusters (or built together as a switchboard assembly).

A cluster will as a minimum contain:

- One 230V AC (1 phase + neutral + earth), 16 A switched socket outlet.
- One 48V AC (1 phase + neutral), 32 A switched socket outlet.
- One 24V AC (1 phase + neutral), 16 A switched socket outlet.

The 230 V socket outlets will be protected against indirect contact by residual current circuit breakers.

The 48 V and 24 V socket outlets will be supplied via a step - down safety transformer providing galvanic isolation from the network.

Socket outlets will be CEE-sockets.

5.8 Traffic Management System (Roads)

The Road Traffic Management System (RTMS) is divided into two parts, Bridge RTMS and Network RTMS, i.e. RTMS on the bridge and on the road network outside the bridge respectively.

The following description apply to the Bridge RTMS, for Network RTMS please refer to CdP 2.

Management of railroad traffic on the bridge is handled by RFI and is outside the scope of this document. However train weight and axle counts for trains entering and leaving the bridge will be monitored as part of Network RTMS. The weighing and counting functions will be implemented in a subsystem called Railway WiM (RWiM).

5.8.1 General

The objective of the bridge RTMS is to:

- manage the traffic flow according to changing actual traffic, road, structural- and meteorological conditions achieving efficient and safe passage for road vehicles on the bridge.
- provide a predictions basis for continuous provision of traffic data for traffic analysis purposes - primarily traffic statistical purposes and simulation of extreme situations for training purposes.
- provide information on predicted and actual road traffic conditions, as well as selected information on rail traffic, to allow the Traffic Management Centre to exercise appropriate management of the road traffic and to assess predicted and actual static loads on the bridge by road and rail traffic.

The RTMS comprises the following main function groups:

- traffic management
  - traffic monitoring
  - traffic prediction

- traffic information
- traffic control

• incident management

- incident monitoring
- recovery coordination

• technical system operation and maintenance

- monitoring of all RTMS systems and modules
- monitoring of all communication infrastructure

• monitoring of selected road weather parameters

• monitoring of train axle weight

• interfacing to other systems

Data collected in the production environment will furthermore form a reference basis for an off-line traffic management simulation with the following simulation functions:

- replay of recorded incidents and traffic information
- verification of traffic management scenarios

The simulation functions will be realised in the training system environment.

Monitoring of vehicles weights also used for calculation of bridge load is handled by the structural health monitoring system (SHMS).

5.8.2 Portals

Traffic management equipment on the bridge will primarily be placed on 2x8 portals each spanning either the eastern or the western side of the road. The use of portals provides the best visibility of traffic management information to road users and makes it possible to arrange a number of road side installations in a relatively compact manner. However, since portals also impact the aesthetics of the bridge infrastructure, points along the road requiring installation of less equipment are only fitted with variable message signs installed on dedicated masts on both sides of the road.

5.8.3 Traffic monitoring

The Bridge RTMS will provide all real-time traffic information required to enable dynamic traffic management to be performed.

Bridge RTMS is also responsible for gathering traffic information for later use in the Structural Health Monitoring System (SHMS) and in RTMS functions such as statistical analysis, traffic simulation, verification of traffic management scenarios etc.

Traffic monitoring makes use of 3 different types of video cameras. All cameras will be installed on the portals above the traffic lanes for best possible view of the road and the traffic.

5.8.4 Bridge traffic load prediction

In order to be able to continuously predict bridge traffic load from road traffic and trains, a running 10 minutes estimate of vehicles on the bridge will be calculated. The road topology within 10 minutes / 20 km of driving distance includes several junctions. However, as a significant part of the road traffic that crosses the bridge may potentially start or end journeys less than 10 minutes travel distance from the bridge, the accuracy of 10 the minute predictions will be limited when traffic flow varies rapidly and/or unexpectedly.

5.8.5 Traffic information

Traffic management is performed using different kinds of Variable Message Signs (VMS). More precisely VMS' capable of displaying text, pictograms, variable speed limits and Lane Control Signals (LCS') will be placed on the portals as illustrated in drawing CG1000 P 2A D P IT M4 GT 00 00 00 01.

In between the portals additional VMS' with capable of displaying variable speed limits are located on separate poles.

The locations of portals and speed limit VMS' are indicated in drawing CG1000 P 1A D P IT M4 GT 00 00 00 01.

5.8.6 Traffic control

5.8.6.1 Moveable barriers, bridge access

Moveable barriers will be installed landside immediately north and south of the bridge. The purpose of these barriers is to prevent any traffic from entering the bridge in cases where accidents or adverse weather conditions make traffic on the bridge unwanted or unsafe.

The barriers will be remotely controllable electro mechanical devices that can efficiently block each of the traffic lanes and the emergency lane. Blocking of the emergency lane will operate independently of blocking of the traffic lanes in order to allow passage of rescue vehicles onto the bridge in any situation.

Each barrier will be equipped with two or three sets of flashing red warning lights, depending on the size of the barrier. The warning lights will flash alternating when the barrier is active.

These barriers are illustrated in drawing CG1000 P 2A D P IT M4 GT 00 00 00 01.

5.8.6.2 Retractable barriers, cross over access

Retractable barriers will be installed in parallel with the left hand crash barriers in a manner that allows crossover openings to be established when needed. When crossover openings are not required, each barrier will act as fully integrated extension to the left side crash barrier providing the same protection to traffic as the normal crash barrier.

The barriers will be remotely controllable electro mechanical devices capable of efficiently blocking access to the crossover point (closed state) respectively providing access to crossover point (open state).

5.8.6.3 Lane Control Signals (LCS)

In order to allow throttling of traffic flow when on-site maintenance or repair works are ongoing and in order to provide a safe working area around an incident site without completely closing down traffic flow, Lane Control Signals (LCS') will be installed. In cases where a complete closure of either the western or the eastern road is required, the LCS units will allow counterflow traffic to take be operated on the remaining open road.

The LCS units will be installed under each portals horizontal beam, centred above each traffic lane and above the emergency lane will be implemented.

For lanes where two-way traffic must be supported, the LCS' will be dual-faced with a built-in safety mechanism that prevents simultaneous green ("open lane" signal) on both LCS'.

5.8.7 Incident Management System (IMS)

The Bridge RTMS will be provided with an Incident Management System (IMS) with the following functions:

- Automatic Incident Detection (AID)
- operator based event verification and logging
- support for operator based incident management

5.8.8 Automatic Incident Detection (AID)

AID will be implemented on the basis of dedicated CCTV cameras with built-in automatic video processing software aimed at detecting the following incident types:

- stationary vehicles in any lane (incl. emergency lanes)
- stationary vehicles in any lay-by
- foreign objects on the roadway (people, lost goods etc.)
- slow moving traffic in any lane.
- traffic in emergency lane when not allowed

The cameras will be fixed (i.e. not pan, tilt, zoom (PTZ) type) and will be able to provide a video quality enabling AID functionality 24/7 in all foreseeable environmental conditions with minimum visibility of 500m[1].

[1] in situations with severely reduced visibility it is assumed that appropriate speed restrictions will be imposed on traffic crossing the bridge, so that reduced AID functionality in adverse weather conditions is being compensated for - at least in part.

The reason for using dedicated cameras is, that the AID function must be available everywhere all the time. The reason for using cameras with built-in image processing capability is, that failure anywhere on any one camera/image processing combination will only affect that one particular camera.

Figure 5.8.8: Example showing an AID system detecting a stopped vehicle on a bridge

5.8.9 Incident management

The Bridge RTMS will be provided with an incident management facility with the following functions:

- preparation and visualisation of incident response plans for handling incident scenarios. The predefined plans will cover all major functions to be handled by the operator in case of an incident
- definition of semi-automated information to be conveyed to road users via VMS signs and text when wanted/required

Semi-automatic implies that information scenarios are predefined but no action is initiated (i.e. no traffic management operation is activated) before being approved by an operator.

5.8.10 Event verification and logging

All automatically detected incidents will require operator verification. To this end the AID-system will be provided with an incident verification form for a formal registration and storing of events.

A similar form will be devised for handling of operator based incident detection.

Verification of events will be protected by the requirement for authentication of any operator before the operator is allowed to perform a verification.

5.8.11 Road weather monitoring

In order to enable safe passage of the bridge in adverse weather conditions, the following road weather related data will be monitored:

- Wind speed and direction (incl. gust)
- Road and air temperature
- Precipitation, type and intensity (rain, snow, sleet, hail)
- Road surface condition (water veil, ice, snow, freezing point etc.)
- Visibility (mist, fog etc.)

Information on road weather conditions will be obtained from a number of Road Weather Stations (RWS') equipped with appropriate detectors for assessment of the above listed parameters. The RTMS will make observations available in the database for any subscribing function to use immediately after completion of the observation.

5.8.12 Automatic monitoring of vehicle weights

The load from all vehicles (on both road and rail) present on the bridge will be continuously monitored by the SHMS. In-data for this monitoring function will be provided by so-called Weigh-in-Motion (WiM) systems for road traffic and Railroad Weigh-in-Motion (RWiM) for railway traffic.

Both north and south moving road traffic will pass WiM-systems when approaching the bridge and after having left the bridge. On the railroad system only trains approaching the bridge will pass an RWiM-system. Trains leaving the bridge will only be detected as "train leaving the bridge", i.e. they will not be weighed.

Both types of weighing systems will provide data on axle and vehicle weights.

All weighing systems will be installed as part of the Network TMS and are thus included on drawings related to that project.

5.9 Communication Systems

5.9.1 General

The aim of the communication systems is to support the Operation and Maintenance staff working on the bridge in their duties, management staff in the Control Room and to support transmission of data for the various technical alarms through the control and monitoring systems.

The communication systems will provide voice and data communication on and inside the bridge by a TETRA radio communication network and a data communication network, and by wired telephones installed in the bridge deck, the towers, substations, equipment shelters, the Control Room and the Toll Station. A gateway to the Public Switched Telephone Network will be included giving the users of the telephone network the possibility to communicate with external subscribers.

Emergency telephones will be installed along both sides of the bridge roads.

It is assumed that Police, Rescue and other emergency services have their own radio communication systems and that their respective technical organisations will provide the necessary radio coverage.

The communications systems are designed using state of the art digital technology in order to ensure flexibility and maximum lifetime of the equipment.

5.9.2 Communication network

The Communication System Works will be established based on a standardized Infrastructure and will use the standardized Ethernet TCP/IP protocol for communication. The BAN will have interfaces to the WAN and the Control Centre. Communication to Toll stations and other relevant buildings within the area bounded by the Toll Station and the Control Centre will be established through the WAN.

The Communications System Works covers establishing of reliable communications on and inside the Bridge, towers and the anchor blocks and will support the following systems:

- Data Communication Network
- Radio Communication Network
- Telephone System
- Emergency telephones
- CCTV surveillance systems
- VMS traffic control systems
- Anti intrusion protection systems
- Anti sabotage/terrorism protection systems
- Bridge control and monitoring systems / SCADA

Other systems and network might also benefit from the Communication System Works as the design is based on a standardized infrastructure environment and a standardized Ethernet TCP/IP environment.

The communication network is designed as redundant ring formed network which will provide very reliable and high availability transmission system.

The network cabling will be fibre optical cables laid as a ring inside the bridge deck in separate routes located in both bridge girders.

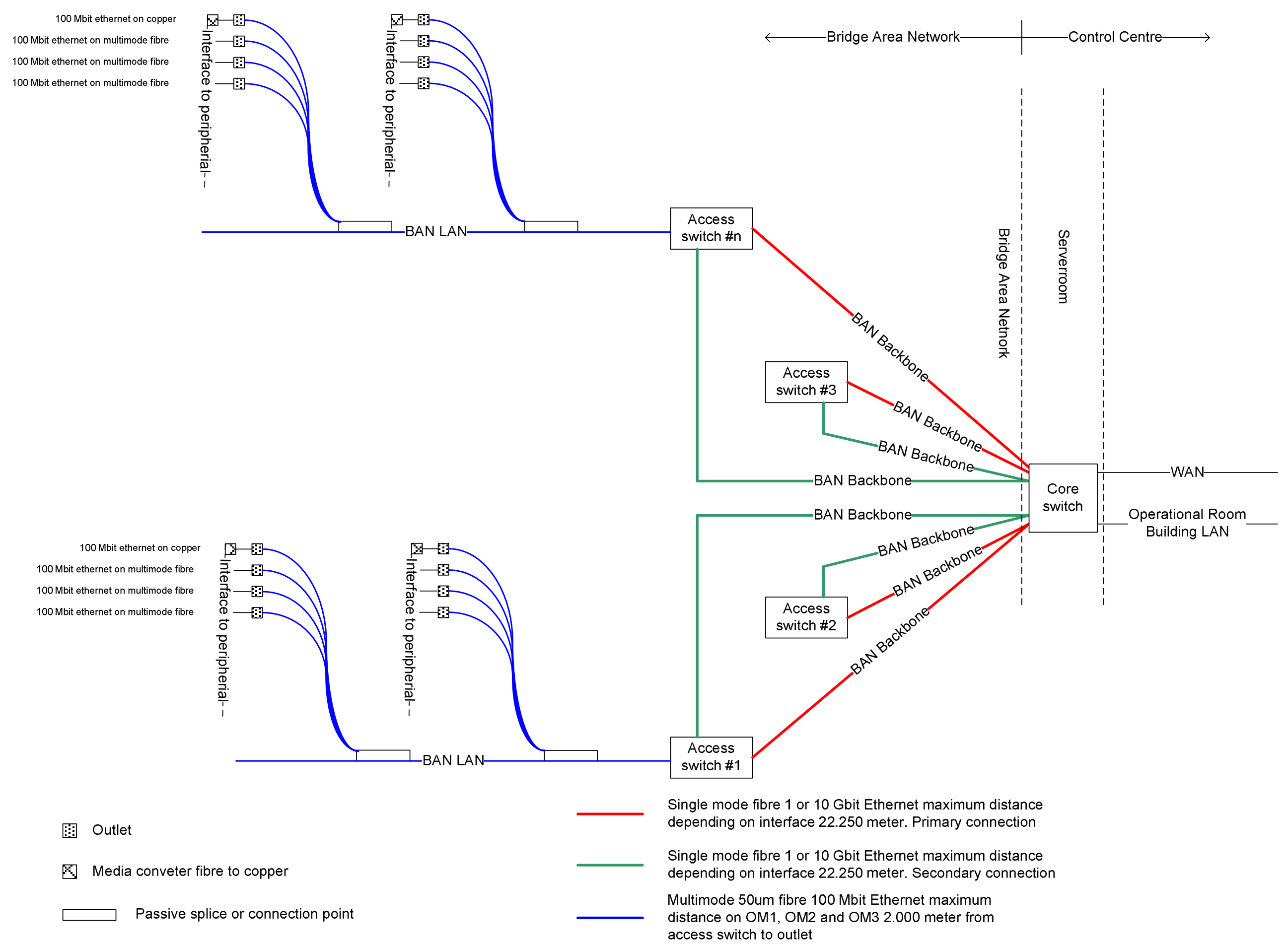


Figure 5.1 Principle layout of the Bridge Area Network (BAN)

5.9.3 Radio Communication System

It is assumed that the radio communication system is only for the Operation & Maintenance staff of the Bridge.

Further, it is assumed that Police, Rescue and other emergency services have their own radio communication systems and that their respective technical organisations will provide the necessary radio coverage.

Further it is assumed that provision of all railway signalling and railway radio communication is outside the Scope of Works, and that design and planning hereof is done by the railway operator.

The radio communication system will provide two way wireless communications for the use of the bridge's operation and maintenance personnel.

Radio communication facilities will be established to cover the Bridge deck and access roads including the road and the area around the Control Centre building and Toll Station.

Further, there will be established radio coverage inside the buildings as well as inside the bridge girders, the towers and the anchor blocks

The radio system will provide voice and low-speed data communication with full privacy between mobile/hand held radios and the operators in the Control Centre of the Bridge. Direct communication between handheld radios or mobile radios will also be possible. Broadcast calls, group calls in predefined groups and in dynamic groups will be possible.

Further, the operator can patch telephone calls to and from the fixed telephone system (PBX) in the control centre building and can also patch calls to and from the Public Switched Telephone Network (PSTN).

Real time information about the geographical position of a hand held or mobile radio units will be transmitted to the operator in the Control Centre.

A Network Management System for the radio communication System will be supplied. The system will provide possibility to remotely monitor and configure the radio communication switch and the base stations.

The radio system will be based on the TETRA standard: TErrestrial Trunked RAdio as specified by ETSI. It is assumed that frequencies will be allocated by the frequency management authorities of Italy in the frequency range for TETRA systems, i.e. 450 MHz.

5.9.4 Telephone System

A telephone system will be provided in order to establish voice communication between the users in the bridge deck, the towers, substations, equipment shelters, the Control Centre, the Toll Station and the Public Switched Telephone Network (PSTN), etc.

The telephone system comprises the switch and peripherals such as telephone sets and fax machines. Remote control and diagnostics will be included with the system.

As a minimum the following user facilities will be available:

- Voice mail and voice response
- Redial last number
- Abbreviated dialling
- Call pickup
- Call forwarding
- Automatic call back
- Direct inward dialling
- Direct outward dialling
- Call detail recording
- Blocking of selected prefixes and numbers

The telephones sets will be provided with display and hands-free option for connection of a head-set.

The telephone system will be based on Voice over Internet Protocol (VoIP) (IP-telephony).

Telephone sets will be connected to the LAN (Ethernet) by through 1000Base-T.

5.9.5 Emergency Telephones

Emergency telephones (S.O.S. Colonne) will be located approximately each 500 m on both sides of the bridge deck. The telephones will provide communication with the Control Room. The telephones will be of the same type as used along the highways in Italy, and be suitable for use in the noisy environment of the road.

The telephones will be illuminated with a built-in lamp, and clearly marked with the text "Soccorso Meccanico, Sanitario e Polizia".

Further, the telephones will be marked with operating instructions in four languages: Italian, English, French and German. It will be possible to identify the telephone that has been activated.

Further, the nearby CCTV camera will be activated automatically and the image presented to the operator in the control room.

The emergency telephones will be provided with an IP-interface box and connected to the data communication network.

5.10 Management and Control and Monitoring Systems

5.10.1 General

The system for operation of the bridge is designed to support real-time management and control and monitoring systems of the road and railway traffic and provide sufficient means for management of bridge maintenance and preparation of analysis and detection of risks in case of extreme weather or/and traffic conditions. This system shall be designed to allow remote (from the control room – Centro Direzionale) management and control and monitoring of the electromechanical installation.

The data communication network is designed as Ethernet redundant network system both at a local and general level. The data communications network is more detailed specified in CG1000-P-2S-D-P-IT-M4-C3-00 00 00 02 General Specifications – Mechanical and Electrical.

The control and monitoring systems hardware will include a 20% of controlling points spare.

The bridge management and control and monitoring system will be interconnected with installations for all approaching parts of the traffic system.

This data input is not limited to daily operation events only, but will focus also on short term and long term prediction of traffic volumes, maintenance needs and optimization of interventions in case of traffic restrictions due to weather conditions, special transports, traffic accidents and safety threats.

The system will ensure the functions:

- Monitoring functions: Physical environment, the structural health, the traffic, the events, the maintenance, and the apparatus and subsystems.
- Supervision functions: security.

- Management functions: Traffic, including simulations and forecasts; sensors, equipment and subsystems; events; emergencies; maintenance planning
- Coordination function
- Safety function: Risk management, infrastructure, users, systems
- Function of information of the state to Concessionaire, police, customers and others.

Language for planning of the system is UML (www.UML.org).

The total Management and Control and Monitoring system will cover functions specified briefly in section 13.1 and consist of the following individual systems interconnected together:

- Management and Control System (MACS)
- Supervisory Control and Data Acquisition (SCADA) system
- Management system for maintenance planning
- Simulation system for structure loads and weather simulation
- Road Traffic Management system (RTMS) for monitoring and management of road traffic, monitoring of railway traffic and traffic simulations
- Structural Health Monitoring System (SHMS)
- Control and Monitoring System (CMS) for control and monitoring of technical systems (M&E)
- Power Management System (PMS)
- Safety System (SSS) for fire detection
- Security system (separate report)

The monitoring and management work stations and large screens for display of pictures and visualisation of alarms and operation data will be located in common Control Room (Centro Direzionale) in Bridge Management building on Calabria side of the bridge.

The Management and Control and Monitring system will be designed as an integrated system of all expert systems listed above.

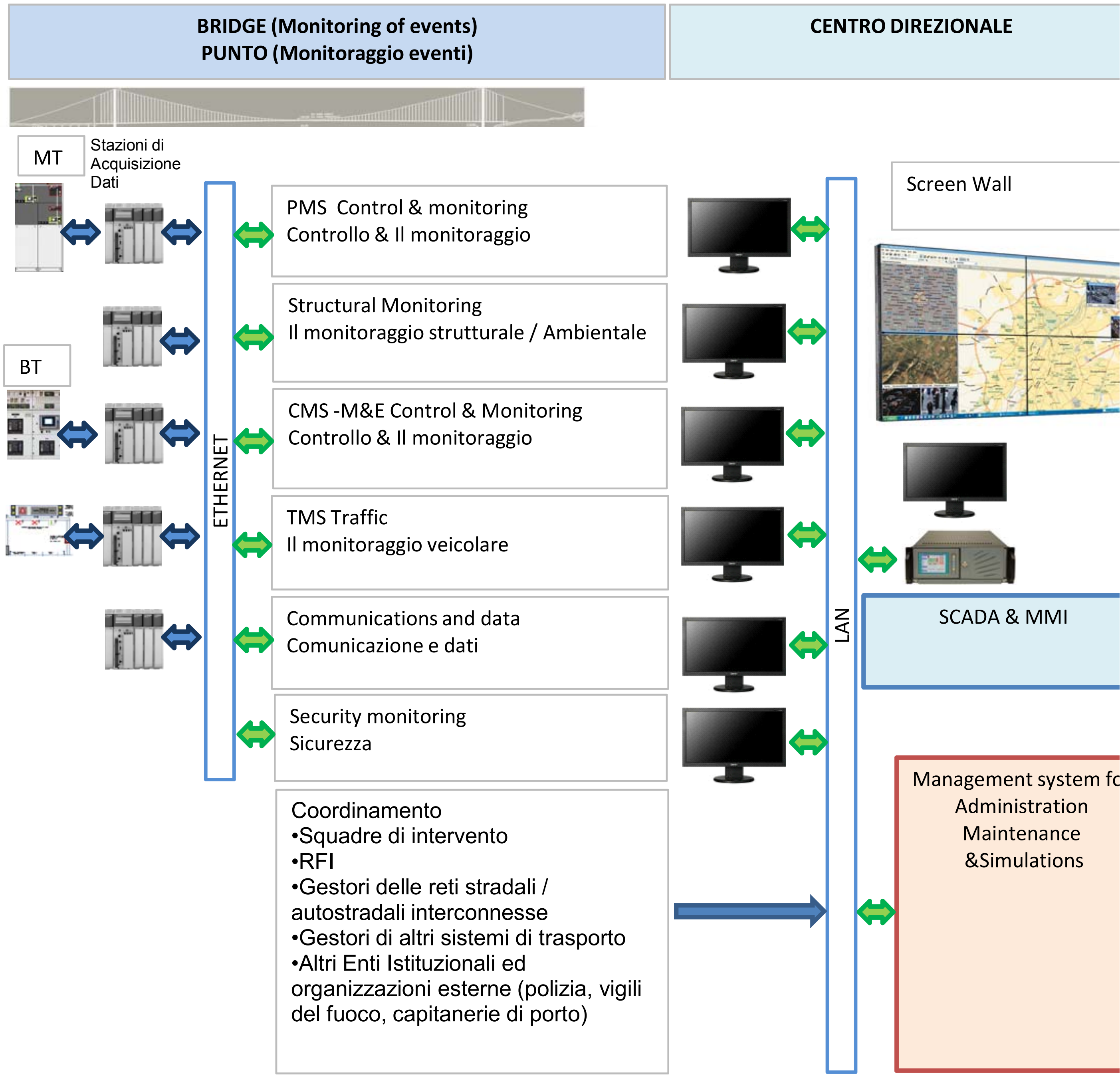


Fig. 5.10 Configuration of the Control and Monitoring System

5.10.2 General Functions and Connected Expert Systems

All technological systems operations will be monitored. The interfaces to these systems field equipment will be included in these technical expert systems and the SCADA will carry out its functions through the central computers of these systems.

The system functions are:

1. Monitoring of:
   - Physical environment and its actions (SHMS)
   - The Works during construction (SHMS)
   - The Works during operation (CMS, SHMS)
   - Traffic (RTMS)
   - Events (SCADA)
   - Systems and sub-systems (SCADA)
   - Safety system (fire detection)
2. Surveillance:
   - Traffic on the Bridge (RTMS)
   - Security system (separate report)
3. Management of:
   - Traffic on the Bridge (RTMS)
   - Safety (separate report)
   - Data and telecommunications
   - Maintenance
4. Information to external parties:
   - RFI (SCADA & telecommunication system)

- Operators of interconnected motorways (telecommunication system)
- Police (telecommunication system)
- Intervention/maintenance teams (telecommunication system)
- Traffic.

5.10.3 Specific Monitoring Functions

In general the following functions will be provided by the technical expert systems in connection with monitoring of the systems:

- Operation status;
- Technical alarms and warnings;
- Operation time for each sub-system;
- Data communication failure;
- Safety related alarms;
- Measured values for technical measurements.

5.10.4 System hardware

The SCADA Man-Machine Interface (MMI) will be designed to view both the total Bridge and its details at the same time on a large display screen arranged by means of a multi-screen system or similar technology. The SCADA system multi-screen display (screen wall) will be used for overall presentation of freely addressed data and pictures from all technical systems installed in the Control Room.

Furthermore, all systems will be provided with two redundant Operator Consoles which will be used for detailed monitoring of each system by operators.

All systems hardware will be redundant and operate as hot stand-by.
The hardware in the Control Room will be supplied by a separate UPS unit class N+1. All field units used for remote data collection and control will be redundant and supplied from local UPS units.
The systems hardware will be latest issue high end hardware from recognised manufacturers.

5.11 Safety and Security Systems

The Bridge will be equipped with an efficient system for fire detection and fighting installations. All electrical substations will be equipped with fire detectors and automatic fire fighting system.

The security related installations include access control and bridge area monitoring. The functions of the security related installations are described in a separate report.

Furthermore, this system will provide monitoring of the railway area with regard to detection of the following events:

- Train presence on the bridge
- Train stoppage on the bridge
- Fire or increased temperature along the track
- Foreign objects on the track (people, lost goods etc.)

The system hardware will be based on military application hardware of robust design, high quality and good corrosion resistance.

5.12 Lightning Protection

5.12.1 General

The Stretto di Messina Bridge is constructed with two more then 400m high towers and a bridge deck suspended on cables. This significant and very large construction will be frequently exposed to atmospheric lightning in spite of location in area with less frequent lightning activity. The frequency of lightings in the Calabria region is in average 1.5-2.5 year/km^2, however higher frequency must be expected around the bridge. Furthermore, experience from operation of high bridges in Mediterranean area proved that not fully protected bridge structures may be seriously damaged by lightning striking tower and bridge cables.

The decision to protect the bridge structures as well as advanced installation on the bridge was taken in early phase of the tender design and the present design explains how the lightning protection system will be constructed.

Lightning protection system and earthing facilities will be provided for the lightning protection and earthing of the installations on the bridge, as well as bridge structures. The lightning protection system will be based on natural parts of the structures which are made of steel, including bridge towers, steel girder and reinforcement bars in the concrete foundations.

In order to reduce the probability of damage due to lightning current flowing in the LPS, the down-conductors will be arranged in such a way that from the point of strike to earth:

- several parallel current paths exist;
- the length of the current paths is kept to a minimum;
- all metallic constructions are bonded to conducting parts of the structure

All electrical systems will be earthed in accordance with the standards.
The lightning protection of following structural elements is designed:

1 Lightning protection of towers.

2 Lightning protection of anchor blocks.

3 Lightning protection and earthing of the bridge deck.

4 Equipotential bonding of all steel constructions and elements of the bridge.

5 Provisions for earthing of M&E installations on the deck and in the towers and anchor blocks.

Definition of the lightning protection zones (LPZ) for the bridge is presented in document CG1000-P-1R-D-P-IT-M4-GC-00 00 00 01 Calculation report, section 5.2.2. The zones on the bridge will be as follows:

- Bridge deck: zone LPZ 0_B
- Inside substation housings on the bridge deck: LPZ 2
- Inside bridge towers: LPZ 2
- Inside bridge girder: LPZ 2

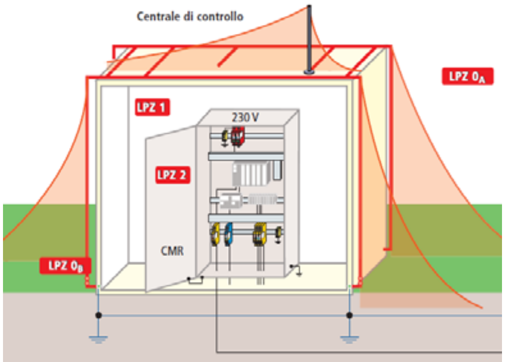


Fig. 5.12 Definition of protection zones for a switchgear - suddivizione della centrale di controllo in zone di protezione da fulminazione LPZ

The following systems are not a part of the present design:

- Lighting protection and grounding of the railway systems (Railway system design)
- Lighting protection of the primary substation buildings (part of the Land works design)
- Lighting protection of the Management building (part of the Land works)

Furthermore, all electrical switchboards will be equipped with lightning arresters/surge protective devices (SPD), chosen in accordance with classification of lightning protection levels ref. EN 62305-1 Protection against lightning. General principles.

5.12.2 Analysis of Risks of Lighting Discharges

Further analysis of risks of lighting discharges will be carried out during Projetto Esecutivo phase in order to detect additional possible risks to both Bridge structures and its electrical and mechanical installations during lightning discharges, as well as to prove the robustness of the protective means to be installed and define the exact construction methods. Results of these analyses will be a part of the design necessary for the manufacturing of equipment and for the installation works.

5.12.3 Towers

The steel construction of the tower forms a natural air termination and down conductor. The construction consists of a number of steel sections and cross beams. The joints of exterior plates are welded by complete penetration welds and the joints of interior plates and stiffening bars are bolted. It is foreseen that the electrical resistance of the joints is sufficiently high to ensure equipotential bonding of the sections and the crossbeams.

The tower cross beams are constructed of steel and will be used as the earthing down conductor for electrical and mechanical installations located in the cross beams.

5.12.4 Tower Foundations

The reinforcement of tower foundations will be equipotentially bonded with the steel construction of the tower and grounded. The reinforcement bars are in a direct contact with the concrete, i.e. are not insulated from the concrete by an external insulation sheet such as epoxy resin.

As a minimum requirement rings will be constructed of horizontal steel reinforcement bars and wires interconnected by means of connection clamps. A ring will be constructed for approximately each 10 m of the foundations depth, starting from the bottom of a foundation. Each of the rings will be connected to the vertical reinforcement bars (down conductors). Each down conductor consists of at least two (2) reinforcement bars. The down conductors will be interconnected. The minimal number of down conductors is four (4).

The uppermost rings will be equipotentially bonded to the basis steel construction of the tower.

The earth termination will be constructed as a mesh network by means of reinforcement bars jointed together in the bottom of foundations by binding, the mesh size max. 2x2 m. A number of reinforcement bars will be jointed together by clamping.

The down conductors will be connected the earth termination network. The earth termination network will be constructed as at least two rings of reinforcement bars clamped together in order to secure electrical connection of these reinforcement bars. The construction will comply with recommendations in EN 62305-3 section 5.4.4, which recommends natural earth electrodes made of interconnected reinforcing steel in the foundation.

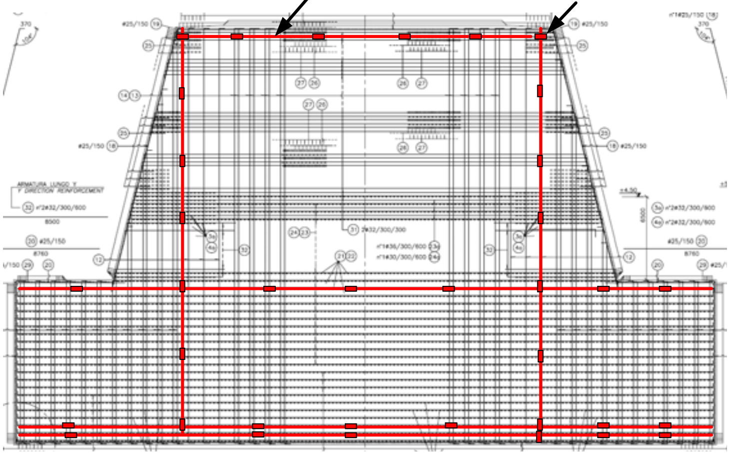


Fig.5.12.4 Foudation earthing system principle for tower foundation

5.12.5 Anchor Blocks

The steel reinforcement in concrete substructure of the anchor blocks is used as the grounding system in the similar way as the structural reinforcement of towers.

5.12.6 Main Cables

The bridge cables will be protected by air termination to avoid damage, by the lighting stroke, of the polyethylene polymer insulation sheet covering the steel core of the cables.

The hand ropes on the cable inspection walkway will be utilized as an air termination. The hand ropes will be equipotentially bonded with steel core of both cables every 30 m by means of a clamp (collar).

The main cables will be equipotentially bonded by means of the cable saddle with the steel construction of the top of the towers.

The anchorage of suspension cables will be equipotentially bonded to the steel reinforcement of the anchor blocks. The following anchorage elements will be connected to the steel reinforcement:

1. Splay saddle
2. Anchorage shoes
3. Anchorages for post-tensioning.

There will be two independent bonding connections between each of those anchorage elements and bonding rings in the reinforcement of anchor blocks.

5.12.7 Hangers

Equipotent bonding between the hangers and the main cables and between hangers and deck cross girders will be established where the mechanical junction do not have sufficient lightning current carrying capacity.

5.12.8 The Deck

The Bridge deck is constructed of steel and will be used as continuous earthing conductor for electrical and mechanical equipment located on the deck. To ensure continuity the expansion joints and bearings must be equipotentially bonded by means of flexible connections.

The buffers between the deck and the towers will be bonded by flexible connection to prevent electrical lightning currents through the buffers.

The deck will be equipotentially bonded with the outlets in the tower foundation.

The deck will be earthed at the connection with Sicilia side and at the connection with Calabria side. The earthing connections will be made to foundation earthing electrodes constructed as described in section 9.5. The resistance of these electrodes will be below 2 ohms. The calculated resistance is approximately 0.1 ohm, ref. Calculation report doc. No. CG1000-P1RDPIT-M4C3000000-01.

5.12.9 Surge Protection of MV Distribution System

All MV substations will be provided with lightning arresters in all cable compartments. The earthing connection for the bridge deck substations will be made to earthing points constructed as welded connection to the steel bridge deck.
The surge arresters will be screened gapless surge arresters (Metal oxide **arrester**) designed for

direct connection onto outer cone bushings in accordance to EN50180 or EN50181. The insulation of the screened surge arrester is made of a highly modified silicone rubber characterized by high tracking resistance, elongation at break and non-flammability. The active part is a metal oxide arrester which meets the requirements of IEC-60099-4 for separable and dead-front arresters. The combination of screened connector and surge arrester exceeds CENELEC HD 629.1 S1 requirements.

The main characteristics of the arrester will be as follows:

For 6 kV switchgear

- Rated current: 10kA
- Operating duty impulse withstand current (4/10µs): 100 kA
- Continuous operating voltage U_c: 6kV
- Rated voltage: 7.5kV
- Residual voltage at 20 kA (8/20 µs): 20kV
- Residual voltage at 40 kA (8/20 µs): 22.5kV
- Energy high current impulse: 5,3 kJ/kV Uc

For 20 kV switchgear

- Rated current: 10kA
- Operating duty impulse withstand current (4/10µs): 100 kA
- Continuous operating voltage U_c: 20kV
- Rated voltage: 22kV
- Residual voltage at 20 kA (8/20 µs): 68kV
- Residual voltage at 40 kA (8/20 µs): 79kV
- Energy high current impulse: 5,3 kJ/kV Uc

Fig. 5.12.9 Switchgear with arrester Raychem, or similar

5.12.10 Surge Protection of LV installations

All main distribution switchboards on the bridge deck will be provided with SPD in the feeder part of the compartment. The SPD will be dimensioned for lighting currents, as required for location in the transition zone between zone LPZ 0_B and zone LPZ 1. The SPD will comply with construction requirements for type 1 in accordance with EN 61643-1 and will have the following main characteristics: 3 x 1-pole 255 V ac 50 kA. The SPDs will be equipped with status signalling contact and optical fibre connection for alarm transmission to the control and monitoring system. Definition of SPDs is specified in the document CG1000-P-1R-D-P-IT-M4-GC-00 00 00 01 Calculation report.

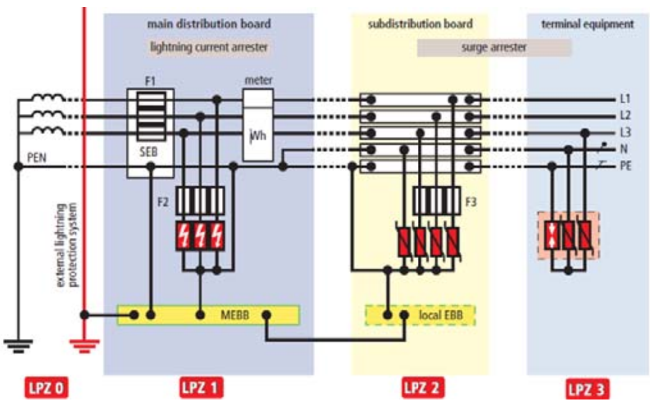


Table 6.4.2-2 Installation of SPD in zones - principle

The SPDs shall be installed in all main switchboards. These SPDs will be located in a transition zone between zone LPZ 0_B and zone 2 and shall be rated for possible induced lightning current as in zone 0_B. The SPDs shall comply with the following minimum specifications:

SPD according to EN 61643-11	Type 1
Nominal ac voltage U_N	230 / 400 V
Max. continuous ac voltage U_C	255 V
Lightning impulse current (10/350) [L,N-PE] I_{imp}	25 kA
Nominal discharge current (8/20) I_n	25 / 100 kA
Voltage protection level [L-PE] U_P	≤ 1.5 kV

All other SPDs in switchboards would be rated for zone 2. The SPDs shall comply with the following minimum specifications:

SPD according to EN 61643-11	Type 2
Nominal voltage ac U_N	230/400 V
Max. continuous ac voltage U_C	275 V
Nominal discharge current (8/20) I_n	20 kA
Short circuit withstand capability at max. mains-side overcurrent protection	50 kArms
TOV voltage U_T	335 V / 5 sec.

All local control switchboards for connection of traffic signs, CCTV etc. will be equipped with SPDs for IT systems in accordance with EN 61643-21:2001. The final protection of this equipment will be decided depending of the equipment manufacturers specifications during the Projetto Esecutivo phase.

5.13 Earthing and Bonding Installations

5.13.1 General Requirements

Earthing and bonding will be established in order to reduce the touch voltages and conduct all insulation fault currents to earth.

The earthing and bonding will comply with the Low Voltage Directive 2006/95/EEC, IEC 60364, IEC 61892.

All the electrical installations will be TNS type earthing system in accordance with IEC 60364.

The earthing system will comprise main earth electrodes, main earth bus, earthing conductors and connectors.

5.13.2 Earth Electrodes

Foundations of towers and terminal piers will be made of reinforced concrete and can be assumed to establish a solid and effective earth electrode which applies to earthing and protection against lightning of the bridge installation.

The connection point to the foundation earth will be fixed earthing terminals of stainless steel located in the top of the foundation structure. These earthing terminals will be provided with Ø10mm screwed connection points for connection of the bridge girder earthing system to the earth electrode.

The connection between the bridge girder earthing system and the earthing terminals at the top of the foundations will be made by means of flexible conductors not less than 95mm² stainless steel or copper.

5.13.3 Earthing System at the Bridge Deck

The steel construction of the bridge deck will be used as earth reference.

The following main earthing bars will be installed at each electrical substation:

- Earthing bar for 6 kV system (PE - bar - 6 kV)
- Earthing bar for 0,4 kV system (PE - bar - 0.4 kV)
- Earthing bar for instrumentation and communication systems (IE - bar)

Each of these earting bars will be located close to the relevant equipment and used as main reference point for these installations.

The main earthing bars in towers will be established in similar way, but skrewed into base plates welded to the tower structure at the substation location area.

The earthing system at land based substations will be established in connection with construction of substation buildings in accordance to IEC 60364.

The earthing system will be TNS system in accordance to IEC 60364.

All transformers will be solidly earthed at neutral point of the 400 V windings.

All other electrical equipment and electrical consumers will be earthed via earth core in the supply cables.

All metallic constructions will be bonded to earth connection points.

5.14 Monitoring of Structures

The Structural Health Monitoring System (SHMS) will be a sophisticated redundant set-up that will provide the owner and operator with important information concerning structural behaviour and safety as well as information that will assist with operation and maintenance planning. The SHMS will also provide a valuable tool for investigating and trouble-shooting unforeseen problematic behaviour such as wind induced vibrations.

5.15 Water Distribution and Fire Fighting

This system is designed for the pressurized water distribution for the following purposes:

- Fire fighting on bridge and towers (Fire hydrant system).
- Fire detection and fire fighting for technical installations.
- Washing system for steel structures.

The fire distribution main on bridge are placed on both sides of the railway girder.

The fire mains are connected to fire hydrants located along the main. The fire hydrants will be accessible from the roads.

In the towers will fire hydrants be located at the base and in each cross beam.

Fire hydrants for bridge will be for 1,000 l/min at 6.9 bar. Fire hydrants for towers will be for 300 l/min at 4 bar.

The utility water valves and the utility water distribution pipes for the bridge are placed on the one side of the railway girder next to one of the fire mains.

Wash valves will be placed along the utility water main for connection to mobile water reservoirs on the Inspection and maintenance gantry for suspended bridge.

Utility water to the wash valves in the tower will be supplied from the pump station located on ground site near the tower base.

The wash valves will be placed next to the gantry access doors inside the towers so they can be reached from the gantries, when the wash water tanks on the gantries are to be filled up.

The fire detection in technical rooms with electronic equipment will be based on smoke detectors connected to fire alarm control panels. In case of detection of fire the system will automatically release fire fighting by means of inert gas. The inert gas containers will be supplied for each technical room.

5.16 Drainage

The purpose of the drainage system is to collect polluted storm water from the bridge and treat it at land based facilities before discharge to the sea.

Secondly the drainage system at the bridge will be provided with overflow possibilities in order to better control surcharge of the drainage system at the bridge.

Drainage of the storm water from the bridge will be achieved by gravity.

5.17 Lifts

All towers will be equipped with lifts based on rack and pinion technology with the following data:

The minimum operational requirements for the access lifts in the bridge tower legs shall be as follows:

Lift cabin floor area	A = 1.6 m^2 (min.)
Lift cabin size (inside)	L x W x H = 1.4 x 1.15 x 2.2 m
Hinged cabin door opening	W x H = 0.8 x 2.0 m
Emergency escape hatch	L x W = 0.8 x 0.8 m

Escape ladder	ø 800 mm
Escape openings in shaft	W x H = 0.8 x 2.0 m
Transparent panels in cabin	W x H = 1.2 x 0.6 m
Operational lift height (level 0 to 25)	H = 362 m
Number of working levels in hoist cage	L = 26
Number of intermediate inspection levels	Li = 26
Capacity live load	Q = 15 kN/20 persons
Equipment (Transformer)	Q = 20 kN
Lift type	Rack-and-pinion lift system
Maximum travelling speed	v = 3 m/s
Motor power (approx.)	60 kW

Cabin construction:

- Cabin structure made from stainless steel profiles
- Inner shell (roof, wall and floor) covered in stainless steel plates
- Transparent inspection windows made of safety glass
- Electrical panels and armatures in plane with inner plates
- Mechanical elements in plane with inner surfaces

Cabin doors:

- Hinged doors in plane
- Escape hatch in top of cabin

The minimum operational requirements for the access lifts to tower base shall be as follows:

Lift cabin size (inside)	L x W = 2.0 x 2.0 m
Hinged cabin door opening	W x H = 1.8 x 2.0 m
Escape caged ladder	ø 800 mm
Operational lift height (approx.)	H = 17 m
Capacity live load	Q = 15 kN/20 persons
Equipment (Transformer)	Q = 20 kN

Lift type	Rack-and-pinion lift system
Maximum travelling speed	v = 3 m/s

Cabin construction:

- Cabin structure made from stainless steel profiles
- Inner shell (walls and floor) covered in stainless steel plates
- Electrical panels and armatures in plane with inner plates
- Mechanical elements in plane with inner surfaces

Cabin doors:

- Hinged doors in plane

Access lifts to tower base in the parking position must be stored in a shelter at the terrain level. Shelter at the terrain level must protect lift from the weather conditions and unauthorised personnel access.

Escape ladder for the access lift must be accessible from terrain level for authorised personnel only.

The platform at tower base inside the tower is at the same level as outside. The platform inside tower gives direct access to lifts inside tower.

5.18 Facilities and Machineries for Operation and Maintenance

The bridge will be equipped with self propelled maintenance platforms.

Furthermore, a number of lifting equipment will be installed at places, where heavy equipment requiring periodic maintenance is installed, e.g. at electrical substations on the deck.

The facilities for maintenance of the bridge installations and structures are specified in the document CG1000-P-SP-D-P-SS-R4-00-00-00-00-01 General access facilities.

The electrically operated access facilities consist of:

- Wagon for suspended deck
- Lifts in towers
- Access facilities to the main cable for inspection and maintenance
- Inspection gantry for girders

5.18.1 Waggon for suspended deck

5.18.1.1 Introduction

The inspection and maintenance of the suspended bridge decks can be executed from internal walkways and mobile inspection waggons running in the entire length of the suspension Messina Strait Bridge. A detailed inspection of the bridge deck interior will probably be carried out continuously.

The waggon (2 pieces) for the roadway girder shall be provided for each girder.

Each waggon consists of a driving waggon and a material waggon which are linked to one another.

The waggon base frames with wheels shall be running and supported on two rails (UNP180 profiles) which are installed in the entire length inside the roadway girder.

The driving waggon will be powered by a battery driven electric motor placed in the bottom of the base frame. The driving waggon will be equipped with a cabin in order to facilitate safe transport of two persons, one driver and one passenger.

Waggons shall be equipped with all necessary equipment to secure safe and comfortable operation (buffers, interconnections, lightning, alarm, control system, communication system etc.).

The waggons will be guided against the rails to ensure safe passage of all openings in the diaphragms in the roadway girder.

5.18.2 Lifts in towers

Tower will be equipped with lifts for access to tower top.

The size of the lift cabin will be (approx.): L x W x H ≤ 2.8 x 1.8 x 2.5 m (approx.)

The minimum operational requirements for the access lifts in the bridge tower legs shall be as follows:

Lift cabin floor area	A = 1.6 m^2 (min.)
Lift cabin size (inside)	L x W x H = 1.4 x 1.15 x 2.2 m
Hinged cabin door opening	W x H = 0.8 x 2.0 m
Emergency escape hatch	L x W = 0.8 x 0.8 m
Escape ladder	ø 800 mm
Escape openings in shaft	W x H = 0.8 x 2.0 m
Transparent panels in cabin	W x H = 1.2 x 0.6 m
Operational lift height (level 0 to 25)	H = 362 m
Number of working levels in hoist cage	L = 26
Number of intermediate inspection levels	Li = 26
Capacity live load	Q = 15 kN/20 persons
Equipment (Transformer)	Q = 20 kN
Lift type	Rack-and-pinion lift system

5.18.3 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.

5.18.4 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.

5.18.5 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

5.18.6 Gantries for suspended bridge

For the main span two gantries shall be provided. The gantries shall be minimum 5 m wide and be self-propelled. All external surfaces of the suspended deck shall be accessible from the gantries, and each gantry shall be equipped with two telescopic platforms in order to give access to the entire height of the cross girders and to the surfaces of the road and rail girder above direct reach from the working area on the gantry.

The suspended bridge deck must be provided with rails at the sides of the service lane for support and transportation of the gantries. The rail arrangements are shown in drawing GC1000-P-AX-D-P-SS-R4-00-00-00-00-01-A Service lane.

The lifting platform shall be movable in the entire length of the gantries and arrangements for fixing/parking shall be included.

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

Gantry	L x W x H = 66.0 x 6.0 x 5.2 m
Boogie distance	D = 9 m (centreline-centreline)
Boogie length	L = 3 m
Telescopic platform	L x W x H = 3.0 x 1.2 x 1.5 - 7.5 m
Hand rail	H = 1.5 m
Wind screen	H = 2.0 m
Gantry rail length	L = 3240 m (pr. side of bridge)
Rail centre distance	e = 59.8 m

More detailed specifications for the gantry are given in the document CG1000-P-SP-D-P-SS-R4-00-00-00-00-02_B_PS-Inspection gantry for girder.

5.18.7 Cable carriage

The minimum travel speed of the carriage must be:

v = 25 m/min.

The travel speed must be valid for the carriage considering an inclination of the main cables at the steepest point.

The cable carriage must be designed to perform all operations in wind speed:

v_b = 20 m/s (10-minute average at the present cable carriage height)

The cable carriage should be equipped with an anemometer. When the wind speed at the present cable carriage height exceeds 20m/s the cable carriage should be parked at the hanger clamp.

The cable carriage must be designed to survive a 50-year storm, when fully loaded or not and locked in parking position at the hanger clamp. The wind speed in this condition will be equivalent to a basic wind speed of:

29 m/s (10-minute average, 10 m above mean sea level)

The design wind speed at cable carriage and hanger 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".

The cable carriage shall be able to travel the entire length of the main cable between the midspan and the saddle and return with a full load, without requiring any additional power supply.

The cable carriage shall be able to travel the entire length of the main cable between the anchor block and the tower top and return with a full load, without requiring any additional power supply.

Power supply in the cable carriage shall be provided from its own power generator. Extra power supply can be provided by electrical cable along the hangers from the service lane.

The design shall provide an optimal and safe operation without damage to any elements or the corrosion protection and without excessive deformation of the handstrands or supports.

Special attention shall be made to the design of the guiding wheels for the towing wire mounted on handstrand posts at every clamp along the cables and guiding wheels within saddle and tower area.