Stretto di Messina

Concessionaria per la progettazione, realizzazione e gestione del collegamento stabile tra la Sicilia e il Continente Organismo di Diritto Pubblico
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EurolinK

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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Opera - tratto d'opera - parte d'opera	Operation and Maintenance
Titolo del documento	Preliminary Inspection and Maintenance Manual, Annex

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1 Executive Summary

The major headings, as detailed in the index of the manual, have been used as the basis for this summary.

1.1 Introduction

Management of large bridges is a complicated task of maintaining the structures and technological systems in an acceptable condition in a cost effective way. This involves numerous multidisciplinary tasks such as: planning, inspection, maintenance, optimisation of resources, preparation of procedures and instructions, coordination and cooperation with external bodies and provision of reliable information to the public on serviceability of the infrastructure.

Since the very beginning of the design, it has been clear that a particular strategy for optimizing management, operation and maintenance of the bridge shall be a fundamental requirement both in relation to the large scale and technical complexity of the structure and because of its economic importance as a "vital" link in the national transport system.

To manage all this, a manual setting out the background and the requirements for operation and maintenance is required. The Operation and Maintenance Manual (O&M Manual) will comprise several documents, principally the Operation and Emergency Manual (O&E Manual) and the Inspection and Maintenance Manual (I&M Manual) together with a number of additional documents with supplementary information that is common to both the O&E and the I&M Manuals. Combined with the Manuals will be a Bridge Management System (BMS) capable of storing inventory data, inspection data, documents, correspondence and budgets in a transparent way.

The Inspection and Maintenance Manual (I&M Manual) comprises a large number of Technical Procedures and Instructions which are based on the information from design and execution phases, from suppliers, etc. These Technical Procedures and Instructions are to be complied with by those involved in inspection and maintenance.

The structure of the I&M Manual is based on the proposed “Table of Contents” given in "Technical Specifications for Maintenance, Control and Management Systems Engineering. Guidelines for the Inspection and Maintenance Plan for the documents of Operation and Maintenance Doc. Code: F.06.04. June 10th, 2004."

The manual covers all parts of the suspension bridge with the exception of particular elements of the railway system e.g. catenary system, signals and their control system, rails (and their embedment) and electrical elements of the railway.

This document will evolve as specific components and equipment are selected and will change based upon inspection findings, component replacement intervals, results from SHMS and feedback from inspection and maintenance personnel. Regular revisions of the document must therefore be anticipated throughout the life of the structure to ensure that it reflects the current condition and requirements. This manual will therefore include a procedure for effective updating, referencing and distribution.

It is anticipated that the I&M Manual will be used in the following way:

- As a basis for planning and maintenance
- As a basis for training of personnel.
- As a source for printing out forms and instructions, check-lists and methods for carrying out tasks.
- As a reference for procedures and instructions.
- As a basis for associated audits.
- As written documentation which can be cross-checked for consistency with respect to other documents relating to inspection and maintenance.

1.2 Design and Construction

The I&M Manual provides a brief description of the bridge including the main technical data.

In due course the manual will be elaborated with:

- Structural design information for the various structural parts for inspection and maintenance purposes.
- Identifying any specified requirement for materials or workmanship that is unique or uncommon practice affecting future inspection and maintenance.

- As built documentation, including inspection reports, testing, certification and acceptance records collected during construction.

1.3 Bridge Reference System

The objective of a Bridge Reference System is to establish a logical and effective filing system for all inventory data of the Messina Strait Bridge.

The purpose is to establish a systematic hierarchical break down of the structural elements and technological systems into smaller elements, with each element having comparable technical properties with respect to operation and maintenance and also identical administrative interfaces. All elements are given individual numbers.

Location codes have also been developed to allow any element to be uniquely referenced to its position on the bridge. To elaborate by an example; the hanger cables will be identified as an element of the bridge suspension system; an individual hanger will be identified as a part of the element "Hangers"; an individual cable (4 nos. for each hanger) will be identified by its location code.

The element hierarchy is used to create a complete list of all the different elements forming the Messina Strait Bridge. The list is used to organise all the inventory data systematically by relating the information to the element numbers.

The distinction between structural elements and technological systems has been selected as the most convenient administrative interfaces. An administrative interface shall not cross any element.

Structural elements may be considered to include the basic parts necessary for the bridge to function, e.g. towers, deck, bearings, cables, carriageway surfacing and barriers.

The technological systems may be considered as the additional, generally mechanical and electrical, parts that are necessary for the bridge to be operated and maintained, e.g. water supply, drainage, lighting, monitoring systems, operation and maintenance related computer systems.

1.4 Inspections

Three types of inspection are used, Routine, Principal and Special. The nature of these inspections depends upon the manner in which each is to be undertaken, e.g. visual, measurements and testing. The table below sets out the nature of the various types of inspections:

Table 1.1 Nature of the various types of inspections

		TYPE OF INSPECTION		
		ROUTINE	PRINCIPAL	SPECIAL
Nature of Inspection	Visual Inspection	YES	-	-
	Close Visual	-	YES	YES
	Detailed visual	-	-	YES
	Functional	YES	YES	-
	Non-destructive testing	-	-	YES
	Destructive Testing	-	-	YES
	Measurements	YES	YES	YES
	Configuration Inspection			YES
	Use of monitoring data in Inspection & Maintenance			YES

Policy: It is the aim to ensure by means of appropriate inspection procedures and programmes that all significant defects and deterioration will be detected to enable the structures to be maintained in a sound and safe condition.

The purpose of the inspection strategy is to allow the changing condition of the bridge elements to be monitored and understood in a way that will allow maintenance work to be planned and performed at the optimum time to ensure the bridge is kept in a safe, operating condition in an economical manner.

Formal inspection procedures will be developed for Routine and Principal Inspections of all structural parts which are identified by Bridge Element Numbers as described in Section 1.3. The scope of each inspection shall be defined within its associated Technical Procedure and Instruction.

Some of the Technical Procedures and Instructions will be dealing with both inspection and maintenance, typically for mechanical bridge elements, where functional inspections are necessary. Functional Inspection is typically an inspection for both the elements function and may include preventative maintenance of the element.

TECHNICAL PROCEDURES

The purpose of a Technical Procedure (TP) is to set out detail and background to a major part of the structural system. (The Bridge cable suspension system and Steel bridge structures are developed as examples of major parts). The Technical Procedure will relate to a number of bridge elements, or a group of elements, and each of these elements will have an associated Technical Instruction. The TP will give reference to the construction specification and to material data sheets and other information of the elements covered by the TP.

Included within the Technical Procedure documents will be a section identifying potential corrective maintenance activities associated with the elements covered by the procedure.

TECHNICAL INSTRUCTIONS

The purpose of the Technical Instructions (TI) is to set out to the inspectors a short description of the elements to be inspected together with details of the inspection work required and, where appropriate, details of the defects likely to occur to that element. Inspectors will be expected to review previous inspection reports for the elements to be inspected and encouraged to seek discussion with the previous inspection team whenever possible. In this way the inspection staff are made aware of the reason for the inspection and are thus more likely to be better motivated when undertaking the task. A Technical Instruction may be targeted towards a number of bridge parts which are best being inspected as a group and will list out any special equipment that may be needed for the inspection. An annex to a TI will include reference proforma and associated sketches.

As examples, Technical Instructions (TI) for parts of the Bridge cable suspension system and Steel bridge structures are appended to the I&M Manual.

It is anticipated that mechanical and electrical installations will each have associated operation and maintenance manuals. Such manuals will be available to the inspection staff and will be included as appendices to this I&M Manual

1.5 Maintenance and Spare Parts

It is an objective of inspection and maintenance to preserve the integrity and safety of the structure in an economic optimal manner while carrying the anticipated loads. For certain parts subject to wear or anticipated limited life (such as wearing parts, bearings and surfacing) maintenance shall include replacement of parts.

Policy : The aims of maintenance are :

- by preventative action to limit deterioration or malfunctioning of parts and equipment to safe and economical levels
- by replacement of worn parts to ensure continuity of desired performance
- by remedying recorded defects with the degree of urgency indicated by the specific Maintenance Manuals, RBI/RCM plans, standards, guides or severity ratings given in the inspection reports or as defined in the Technical Procedure for Principal Inspection to ensure continued structural integrity and public safety

An assessment of each bridge part will also be made to consider whether it is necessary or prudent to maintain a supply of spare parts. Mechanical and Electrical elements will require some spares to be held whilst some bespoke items may justify spares being held because future replacement costs would be disproportionate to unit costs during construction. Where spare parts are suggested consideration will be given to the number of such parts to be stocked.

Spare parts are to be stored in a secure area where they can be protected from deterioration, loss or damage. An inventory system will be developed to manage and control storage, identification and timely replenishment of spare parts.

1.6 Operational Constraints

Inspection and maintenance personnel will be required to work in a variety of locations throughout the structure and several activities will need to be carried out in locations where there will be obvious or less apparent hazards. It is essential therefore for all inspection and maintenance personnel to be aware of the operational constraints that will affect their activities. Operational procedures for working in confined spaces, at height, within the railway envelope, close to, or above, live traffic etc. will be considered and developed for inclusion in the O&E Manual.

1.7 Safety and Security

Procedures for all aspects of safety and safe working will be included in the O & E Manual. The I&M Manual will therefore refer to the O&E Manual but will emphasise the need for safety to be at the forefront of all activities on the Messina Straight Bridge and the requirement for all inspection and maintenance personnel to be fully trained, familiar and supportive of all health and safety procedures.

Security procedures and instruction will also be developed in connection with preparation of the Operation & Emergency Manual.

1.8 Quality

The general policy is to ensure that anyone undertaking works on the Messina Strait Bridge shall be aware of and adhere to the appropriate National and International Standards and Codes including taking account of ISO 9002 and environmental legislation and standards.

A summary of

- expected staffing levels for inspection and maintenance teams based on the proposed organization in the Operation and Maintenance Manual [1] including description of necessary equipment
- expected level of qualifications and training for the various grades within the inspection staff including training

is described. The section must be elaborated when the staff organization is known.

Method statements should be developed for "standard repairs" during construction when the contractor's method statements are known for the work concerned.

1.9 Collection, Recording and Analysis of the In-Service Data

The objective is to describe the strategy for the collection, recording and analysis of the in-service data the inspecting and maintaining authority is required to collect and perform.

The data are recorded in the Maintenance Log.

The purpose of the Maintenance Log is fulfilled by:

- keeping a chronological registration of inspections and summaries of the inspection reports.
- keeping a chronological registration of the condition and any operational disorder.
- keeping a chronological registration of maintenance works.
- supporting other bridge management activities by supplying above data needed for the particular emergency, operation and maintenance activities.

All data in the log are related to the hierarchical structure of the Messina Strait Bridge, refer to Section 1.3.

Use of electronic signatures to be used in reports prepared by inspection and maintenance staff will be developed.

All data should be stored in the database of the Bridge Management System and files should be kept to a minimum after the registration of the data in the database.

1.10 Programmes

An outline inspection programme covering Main Cables, Towers and Box Girders is appended. The programme has to be elaborated to cover all other structures. Proposed frequencies for inspection of other structural elements based on Failure Mode, Effects and Criticality Analysis (FMECA) and Inspection and Maintenance Activity Analysis (IMAA) are discussed in the report for Reliability Based Inspection (RBI) and Reliability Centred Maintenance (RCM), ref. [2].

A Maintenance Programme based on the performed Life Cycle Cost Study, ref [3] is included in the Manual.

A Maintenance Programme for all technological systems and equipment should be developed when the suppliers of the various systems and equipment are known.

1.11 Technological Systems

The various Technological Systems are briefly described together with the expected extent of inspection and maintenance activities to be executed by the Inspection & Maintenance Organization.

2 Introduction

Management of large bridges is a complicated task of maintaining the structures and technological systems in an acceptable condition in a cost effective way. This involves numerous multidisciplinary tasks such as: planning, inspection, maintenance, optimisation of resources, preparation of procedures and instructions, coordination and cooperation with external bodies and provision of reliable information to the public on availability and serviceability of the infrastructure.

To manage all this a manual setting out the background and the requirements for operation and maintenance is required, as well as a management system capable of storing inventory data, inspection data, documents, correspondence and budgets in a transparent way.

The Inspection and Maintenance Manual (I&M Manual) comprises a large number of procedures and instructions which are based on the information from design and execution phases, from suppliers, etc. The procedures and instructions are to be complied with by the staff (Inspection & Maintenance Organization, contractors, suppliers, consultants, etc.) involved in inspection and maintenance.

The Inspection and Maintenance Manual will be supported by a Bridge Management System [5] (BMS) that is able to handle all in-coming and out-going data.

The structure of the manual is based on the proposal to Table of Contents given in "Technical Specifications for Maintenance, Control and Management Systems Engineering. Guidelines for the Inspection and Maintenance Plan for the documents of Operation and Maintenance. Doc. code: F.06.04. June 10th, 2004."

The report/manual covers the suspension bridge inclusive the main cables, and the Terminal Structures.

For the railway bridge girder the manual only covers

- girder
- masts
- platform
- rail fixing to girder
- steel plates limiting the rails
- anti-derailment arrangement
- surfacing on the girder deck

and not

- the catenary system
- signals and their control system
- rails (and their embedment)
- electrical elements.

2.1 Overall Structure of Operation and Maintenance Manuals

Operation and Emergency (O&E Manual) and I&M Manual form the overall Operation and Maintenance Manual (O&M Manual) of the bridge. The I&M Manual shall be seen in conjunction with the O&E Manual and the two manuals shall have documents common to the extent they are the same.

O&M Manuals comprise:

- O&E Manual - for list of contents refer O&E Manual, ref. [1].

- I&M Manual.
- O&M Common Manuals with supplementary information.

2.1.1 O&M Common Manuals

1 Guide to Bridge access (common position system)

2 Drawings (cf. Bridge Management System (BMS) where all drawings will be available)

3 System Manuals (/computer accessible system manuals)

4 Design Basis

5 ORA Basis

6 RBI and RCM Basis, ref. [2]

7 LCC Basis, ref. [3]

8 BMS manual (/computer accessible system manuals)

9 Emergency procedures of external parties

10 Safety Concept, COWI doc. no. A09055-NOT-3-004 (5th June 2010).

2.2 Intended Use of Inspection and Maintenance Manual

The I&M Manual is the documentation of the agreed procedures and instructions to be applied for the bridge staff and external parties undertaking inspection and maintenance of the bridge.

It is anticipated that the I&M Manual will be used in the following way:

- As a basis for planning inspection and maintenance
- As a basis for training of personnel.
- As source for printing out forms and instructions as check-lists and other basis for carrying out tasks.
- As reference for occasional look-up on procedures and instructions.

- As a basis for audits.
- As a written document which can be cross-checked for consistency with respect to other documents handling inspection and maintenance.

This document will evolve as specific components and equipment are selected and will change based upon inspection findings, component replacement intervals, results from SHMS and feedback from inspection and maintenance personnel. Regular revisions of the document must therefore be anticipated throughout the life of the structure to ensure that it reflects the current condition and requirements. This manual will therefore include a procedure for effective updating, referencing and distribution.

2.3 Design Philosophy for Future Maintenance

The design life of the Bridge is assumed to be 200 years.

The overall design philosophy for future maintenance of the Messina Strait Bridge is to minimise deterioration of strength due to corrosion, cracking, damage or other causes. Allowance is made for limited wear of moving parts. In order to preserve their intended reliability all elements shall be inspected and maintained, with parts replaced or repaired as necessary to ensure that their capability is not diminished during their service lives.

With regard to fatigue endurance, continued structural integrity is to be ensured through early life inspections to detect and address construction related defects followed by periodic inspection to detect cracking; all inspection intervals are related to predicted fatigue damage rate and to the structural importance of individual parts. Cracks detected are to be monitored or repaired as dictated by their severity and location.

In the absence of defined actions in this manual, on detection of any other apparent defect, the significance of that defect shall be reviewed and assessed by the Inspection & Maintenance Organization.

Inspection and remedial work, if necessary, shall be agreed with SdM, and carried out in accordance with procedures developed from those contained herein and agreed by SdM.

Since the very beginning of the design, it has been clear that a particular strategy for optimizing management, operation and maintenance of the bridge shall be a fundamental requirement both in relation to the large scale and technical complexity of the structure and because of its economic importance as a "vital" link in the national transport system. Such a strategy was aimed at achieving best performances in terms of:

- Safety, durability and value of the structure, i.e. keeping the structure efficient and in good condition and maintaining its value for its entire life-cycle.
- Effective and economic maintenance; i.e. achieving the above target with minimum expense.
- Safety of users and maintenance personnel.
- Service continuity and quality; i.e. to minimise the need for traffic management during maintenance activities.

Therefore, in the design, components with long service life have been chosen, e.g.:

- Elastomeric wrapping of main cables 30 years
- Sealing around clamps 15 years
- Surfacing in slow lanes 20 years
- New top coat at ext. surfaces on suspended deck and towers 30 years
- Surfacing* of roadway girder 40 years
- Surfacing of railway girder 30 years
- Galvanisation on crash barriers 50 years
- Galvanisation on wind screens 50 years
- Roadway expansion joints* 50 years
- Railway expansion joints* 60 years

For components mentioned above marked with *, maintenance works before replacement are foreseen, please refer the Maintenance Programme in Appendix 11.2.A.

2.4 Operational Controls

The operation of the crossing is to be controlled in accordance with an Operation and Emergency Manual which includes, among other things, the controls which are to be applied during inspection and maintenance activities. It is essential that these controls are observed during the performance of the activities in this Inspection and Maintenance Manual.

It is essential for all inspection and maintenance personnel to be aware of the operational constraints that will affect their activities. Reference must therefore be made to the associated manuals (especially the O&M Manual) and documents covering operational, safety and control measures for all users of the bridge.

Inspection and maintenance activities will need to be assessed to identify the risks that may arise from each activity. To varying extents, depending upon the location, timing and procedure for an activity, there will be risks to:

a) The inspection and maintenance personnel.

b) The users of the crossing.

c) The structural or operational integrity of the bridge and bridge facilities.

Inspection and maintenance personnel will work in a variety of locations including confined spaces, at height, in areas exposed to weather, live traffic and other hazards. Inspection and maintenance activities may interfere with the users of the crossing either physically, e.g. traffic management, or visually, e.g. operatives working on the main cable.

Operation and Emergency Procedures will be developed to address all envisaged activities. Inspection and maintenance personnel will be required to adhere to the appropriate procedures and to be vigilant in assessing their effectiveness. All personnel will be required to comply with the O&E Manual.

2.5 Duties of the Inspection & Maintenance Organization

The Technical Manger will have overall responsibility for the Inspection and Maintenance activities of the bridge. He will be in charge of the management of the SdM Inspection & Maintenance Organization. Please refer to the Operation and Emergency Manual for a full description of the Inspection & Maintenance Organization.

Inspection and maintenance management activities are related to all elements of the entire suspension bridge.

Inspection and Maintenance management includes among others:

- Inspection and Maintenance planning including budgeting of work.
- Execution of inspection and maintenance work.
- Management, supervision and training of maintenance personnel.
- Cooperation and coordination with the Management for Operation and Emergency.
- Review and Update of this Inspection and Maintenance Manual including amendments to the Technical Procedures and Instructions.
- Surveillance and processing the results including updating according to the RBI and RCM Methods.
- Updating and continuation of LCC analyses undertaken during the design period and continuation of RBI and RCM updates. Coordination with the Bridge Management System (BMS).

2.6 Aims of Inspection and Maintenance

The main objectives for inspection and maintenance are:

- Maintain traffic (road and rail) safety.
- Minimize road and railway user interference and thereby reduce the influence on the environmental and societal costs from traffic due to delays.
- Focus on preventative maintenance and combine preventative maintenance with inspection and repairs, to make the best possible use of available resources.
- Use the available resources in the most efficient and cost-effective way.
- Maintain a satisfactory visual appearance.
- Protect the environment.

- Engage maintenance personnel to carry out their tasks efficiently and safely.
- Optimisation system for bridge improvements and maintenance.
- Enable the management to determine economically optimum inspection and maintenance standards and strategies for the structures and their associated systems.

2.7 Document Control

The Inspection & Maintenance Organization (IMO) (either it is SdM's own staff or an external contractor) shall not vary or modify the requirements for the inspection and maintenance of the Messina Strait Bridge without permission of SdM.

Further, this Manual and any supporting documentation, including Appendices, may be amended or extended by SdM at any time. The IMO will be issued with the relevant changes for insertion in this Manual. Following receipt, the IMO must implement any changes that effect the management, operation and maintenance of the Messina Strait Bridge as soon as possible.

The IMO shall store and maintain all existing records given to him by SdM and these records must be available for use by SdM. The IMO should also keep SdM informed of the storage location.

The IOM shall maintain full and detailed contemporary records in a form acceptable to SdM of all works undertaken in connection with the Messina Strait Bridge.

<u>Document Control System</u>

An Electronic Document Management System (EDMS) will be developed.

The objective of EDMS is to register and give access to the following documentation:

- All as built documentation (drawings and specifications).
- Operation manuals and Inspection & Maintenance manuals prepared by designers, contractors and suppliers (all of which will be included in the general Operation & Emergency and Inspection & Maintenance manuals as appropriate).
- Spare parts lists.
- Administrative and O&M technical procedures and instructions prepared by the O&M Organization.

- Any other documentation to be used by the O&M organization.

It is assumed that EDMS at the end of the construction period is equipped with an "Inspection and Maintenance Oriented User Interface" meaning that facilities to operate with documents in the Operation and Maintenance stage is already included in EDMS. At the end of construction stage all As Built Documentation is available through EDMS.

During the service life of the structure there will be changes and updates to the mechanical and electrical systems as well as structural repairs, alterations and other works. Such changes will result in the need for manuals and as-built records to remain in line with the condition of the structure.

The I&M organization will have easy access to all current versions of maintenance documents via EDMS.

2.8 Access by Others

Arrangements shall be made by the Inspection & Maintenance Organization (IMO) to provide access and all assistance to SdM and its agents to inspect the structures and equipment and to any works being carried out.

The IMO shall also provide those Authorities with Statutory obligations access to the Messina Strait Bridge to carry out such obligations and other relevant work.

Such access shall be subject to reasonable notice by the Authorities except in the case of an emergency.

Access to all parts of the structure where public access is not permitted will be subject to control procedures as outlined in the O&E Manual. Access to these parts of the structure will be available to trained and competent IMO personnel.

3 Design and Construction Information

The Messina Bridge provides a road and rail connection between the mainland of Italy and the island of Sicily. The suspension bridge has a main span of 3,300 metres with a total distance between anchorages of 5,070 metres; it has a design life of 200 years.

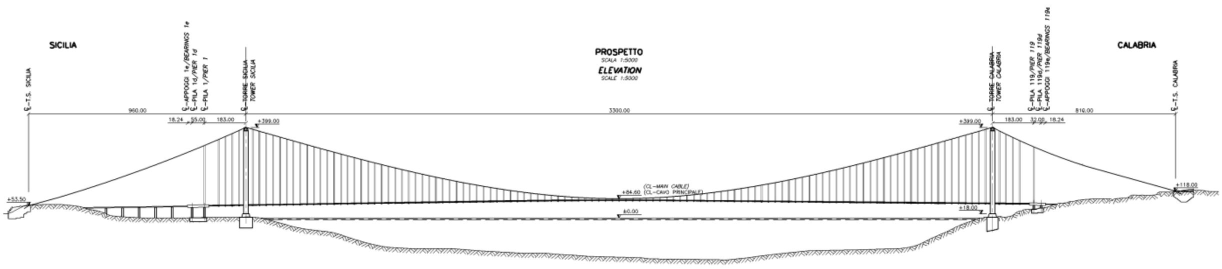

Figure 3.1 Main bridge longitudinal section

The suspended deck is formed by three streamlined longitudinal boxes. The outer boxes carry the road carriageways, each with two 3.75 m wide road lanes plus and emergency lane with a cantilevered Maintenance track. The central box carries two railway tracks with associated inspection strips. The three longitudinal boxes are carried by transverse box girders spanning between the hanger planes. The internal areas of these boxes are to be dehumidified to prevent corrosion. The total width of the bridge deck is approximately 61 metres with the distance between the main cables of 52 metres.

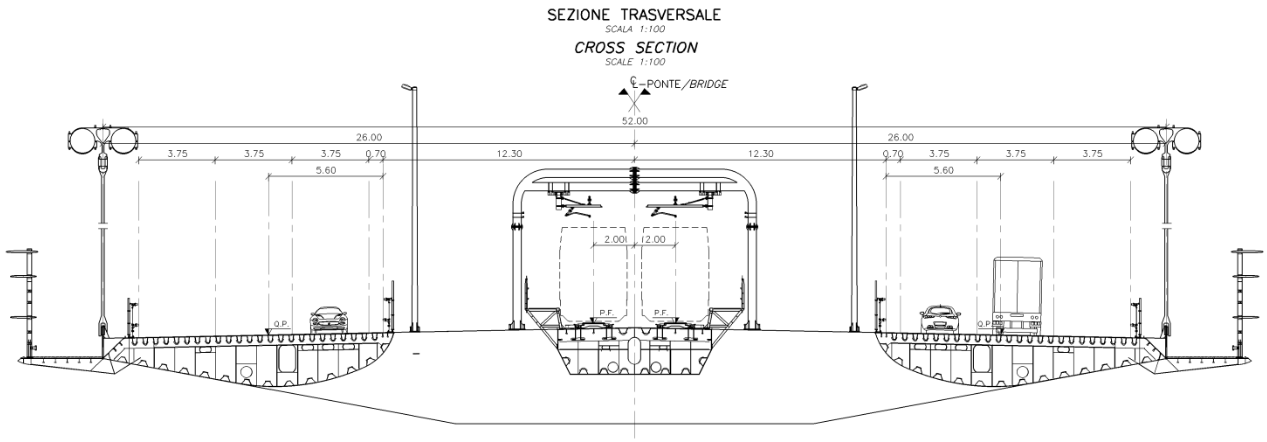

Figure 3.2 Main bridge cross section

The suspension system comprises two pairs of main cables. In the main span each 1.24 metre diameter cable is made up of 325 strands with each strand comprising 127 wires of 5.4mm diameter. Due to slightly higher loading in the side spans, there are eight additional strands per cable on the Sicilia Side Span and six additional strands on the Calabria side span. These are wrapped in an elastomeric sheath (though an alternative with S-shaped interlocking wrapping wire, elastic primer and paint is under consideration) and dehumidified. The hangers from the main cables are in groups at 30 m centres and are connected to the transverse box girders. Hanger diameter varies up to a maximum of 160mm, with the hangers adjacent to the towers being about 300 m long and each weighing about 30 tonnes. The shorter hangers are designed to incorporate spherical bearings at both ends to allow rotation of the pinned joints about the longitudinal axis of the bridge. The total amount of structural steel used in the suspension system is about 167,000t for cable wires, 5,500t for the hangers and 7,000t for the castings (cable clamps and saddles).

The towers rise to a height of 400 m above sea level and carry the vertical load applied from the main cables. The steel plate thickness varies from 50-65mm over most of the height but increasing to 90mm in the lower sections. The total amount of structural steel is about 52,500t per tower. The internal areas are painted and also dehumidified.

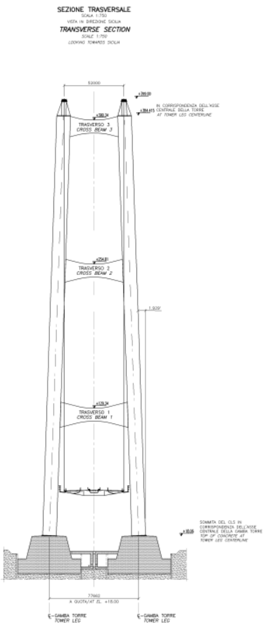

Figure 3.3 Tower

Access to all parts of the structure is provided. A cantilevered maintenance service lane runs along each side of the carriageway deck and a continuous walkway runs alongside each side of the railway envelope. Four underdeck travelling gantries are envisaged, spanning the full width of the bridge deck; these gantries incorporate scissor lifts to enable close access to all areas of the underside of the structure. A complete system of internal service walkways is provided within the deck sections as well as inside the towers. Each tower leg is provided with service walkways, large internal lifts and emergency stairs. All external surfaces of the towers and crossbeams can be reached using a system of suspended platforms. A cable trolley supported on the handstrand ropes provides a system for access to all exterior parts of the main cables; these trolleys incorporate access platforms that can be lowered and raised to allow close inspection of the hangers. Bearings, expansion joints and anchorages all have similar provisions for effective and safe access.

Figure 3.4 Configuration of the suspended deck

3.1 Structural Design Information Relevant to Inspection and Maintenance

Initial meetings have been held with a number of the design team leaders to discuss issues within the various areas of the bridge. The meetings provided an opportunity to discuss and exchange views on the current design developments and their effect on future inspection and maintenance issues. Meetings have been held with the following design team leaders:

- Towers and Cross beams.
- Cable suspension system.
- Bridge Deck structure
- Articulations (bearings, movement joints and buffers)

- Foundations and Anchorages
- Structural Health System.
- Carriageway Surfacing.

Notes relating to these meetings are included as **Appendix 3.1.A**.

Further meetings with the design team leaders will be arranged to allow additional exchanges to be made as the design develops. It is expected that several inspection and maintenance concerns can be addressed as part of the design development. Similarly, any concerns of the designer can be identified and hence incorporated into the TPs (Technical Procedures, refer section 5.10) and TIs (Technical Instructions, refer section 5.10) for the associated elements. In due course, the appropriate design team will be tasked with commenting on the technical procedures and instructions that are developed for the particular sections.

3.2 Contract Specifications for Materials and Workmanship

It was noted in the meetings detailed in 3.1 above, that specifications will develop with the design. There were some special items noted in the discussion that will need to be regularly inspected but it was also noted that it is presently too early to be specific on associated inspection and maintenance requirements. Further meetings with the design teams will be required once the various design requirements are determined. The TPs and the TIs will be revised and updated as these discussions develop.

3.3 As-built Drawings including Sketches, Construction Method Statements

As built drawings including sketches and construction method statements will be collected during construction.

3.4 Supervision Reports, Testing, Certification and Acceptance Records

Supervision reports, testing, certification and acceptance records will be collected during construction. This will include any aspects of non-compliance of the constructed works with the drawings or specification. Any aspects that may be considered to have an unanticipated influence on operation, inspection, maintenance or safety should be highlighted during the construction phase to allow the potential consequences to be assessed. Present anticipated inspection intervals during the operation phase may need to be reviewed as a consequence of knowledge gained during the construction phase.

The collected data concerning any aspects of non-compliance of the constructed works with the drawings or specification should be stored in the database of the Bridge Management System and files should be kept to a minimum after the registration of the data in the database.

4 Bridge Reference System

4.1 Element Hierarchy

4.1.1 Introduction

The objective of a Bridge Reference System is to establish a logical filing system for all inventory data of the Messina Strait Bridge.

The purpose is to establish a systematic hierarchical break down of the structural elements and technological systems into smaller elements, with each element having comparable technical properties with respect to operation and maintenance and also identical administrative interfaces. All elements are given individual numbers (or a combination of characters).

Once elements have been allocated unique reference numbers, location codes are applied to allow individual components to be referenced. By this method, for example, any individual bolt within any cable clamp assembly can be uniquely identified by its element reference and its location reference.

The element hierarchy is used to create a complete list of all the different elements forming the Messina Strait Bridge. The list is used to organise all the inventory data systematically by relating the information to the element numbers.

The distinction between structural elements and technological systems has been selected as giving the most convenient administrative interfaces. An administrative interface shall not cross any element.

E.g. maintenance of the roadway, the crash barriers and the drainage may be subcontracted in different packages. Therefore the carriageway is split into a number of elements.

Structural elements are described in detail in Section 4.2 and may be considered to include the basic parts necessary for the bridge to function, e.g. towers, deck, bearings, cables, carriageway surfacing barriers and dehumidification equipment.

The technological systems are described in Section 4.3 and may be considered as the additional, generally mechanical and electrical, parts that are necessary for the bridge to be operated and maintained, e.g. electrical (e.g. lighting), monitoring, railway, operation and maintenance systems.

Inevitably, there is an overlap between Structural Elements and Technological Systems and, where this exists, the element has been allocated.

If other administrative interfaces later may be considered convenient crossing elements as defined in the present element hierarchy the element of concern should be split into two parts.

In the subsections below, the basis of the numerical systems developed for structural elements and technological systems is clarified.

(The element hierarchy will be incorporated in the element structure for the whole link when it is available. Necessary changes have to be done.)

4.2 Structural Elements

4.2.1 General

The element hierarchy for the structures is based on a break down into 8 element levels with individual properties and the assumption that the whole link is at level 1.

A further break down is possible applying up to 6 location codes to each element at level 2 - 7.

The location codes are used to record positions on individual elements with identical - or almost identical properties - except for the location. The location codes may be used for purposes of inspections to pinpoint exact positions of a defect.

The two first location codes are stationing at start of the element and at end respectively. The third location code is used to apply a code number to each element at level 5 - 7 e.g. to give a detailed location of a defect, reference to section 4.2.9.

The element hierarchy for structures at level 1 to 4 is shown in table 4.1 together with the parallel identification by characters used in the Project.

Table 4.1 Element Hierarchy, Structures, level 1, 2, 3 and 4

Element no.					**Description**
L1	**L2**	**L3**	**L4**		**Hierarchy element**
ID	**ID**	**ID**	**ID**	**ID$_{Character}$**	
1				**?**	**Messina Link**
	1			**P**	**Suspension Bridge**
		1		**ST**	**Substructure**
			1	F3	Tower Foundation
			2	B4	Anchor Blocks
			3	F4	Terminal Structure Foundations
			4	S6	External Arrangements
		2		**SV**	**Superstructures**
			1	T4	Towers
			2	S7	Suspension System
			3	I3	Deck
			4	S8	Terminal Structures
		3		**SS**	**Secondary Systems**
			1	R4	Secondary Structures
			2	A0	Articulations
			3	P2	Platform

The element hierarchy for structures at level 2, 3, 4 and 5 is presented in **Appendix 4.2.A.**

4.2.2 Element Hierarchy, Level 1 and 2

It is assumed that the whole Messina Link is the only element at level 1.

There may be other elements at level 2 than "Suspension Bridge", but within the scope of this manual it is the only element at level 2.

4.2.3 Element Hierarchy, Level 3

Level 3 elements include Substructure, Superstructures and Secondary Systems.

4.2.4 Element Hierarchy, Level 4

Each of the Level 3 elements is further divided at Level 4, for example Level 3 - Superstructure separates at Level 4 to identify Towers, Suspension System (cables etc), Deck and Terminal Structures.

4.2.5 Element Hierarchy, Level 5

At Level 5, each of the level 4 elements is further divided. As mentioned above the element hierarchy for structures at level 2, 3, 4 and 5 is presented in **Appendix 4.2.A.**

In the column left of the column "Hierarchy Element" identification in characters is shown. The identification is used during construction, e.g. substructure element "Tower Sicily" will have the figure identification 1.1.1.1 and the character identification P-ST-F3-TS.

The element hierarchy is dictated by the Project for level 1 - 5, though it is proposed that some further elements to be added at level 5. The proposed additional elements are marked with "question mark" for the character identification on **Appendix 4.2.A.** Several elements are also proposed to be added on the lower levels (level 6, 7 and 8) and they are also marked with "question mark".

4.2.6 Element Hierarchy, Level 6

Some of the level 5 elements are subdivided into level 6 elements.

The subdivision is mainly based on subdivision of

- Substructures:
  - Tower Foundations (Sicily and Calabria) into Leg North-East, Leg South-West and Cross Beam
  - Terminal Structures Foundations (Sicily and Calabria) into Foundation and Piers
- Superstructures:
  - Towers (Sicily and Calabria) into Leg North-East, Leg South-West and Cross Beams
  - Suspension System and Deck into whether the structures belong to the Main Span, Side Span Sicily or Side Span Calabria
  - Terminal Structures into whether the structures belong to the Longitudinal Steel or the Slab
- Secondary Systems:
  - Bearings and Expansion Joints into whether the structures belong to the Railway or Roadway Girder (either in the traffic direction of Sicily or Calabria)

The element hierarchy for level 2 - 6 is shown in **Appendix 4.2.B.**

4.2.7 Element Hierarchy, Level 7

Few elements at level 5 and several elements at level 6 are subdivided further, e.g. subdivision of tower legs into an element for each of the 21 segments, hangers to an element for each hanger, cable clamps to an element for each clamp and main cables into 4 elements, one element for each cable.

The railway and roadway girders are also subdivided into elements, an element for each section between two adjacent hangers.

Appendix 4.2.C shows all elements at level 2 - 7

4.2.8 Element Hierarchy, Level 8

Level 8 elements are developed from level 7 to give even a further detailed break down of the specific element.

So far developed level 8 elements are shown in **Appendix 4.2.D.**

Location codes are not applicable for elements at level 8, when it is found that the detailing of the superior level is sufficient.

For elements at level 8 the purpose is in several cases only to be able to distinguish between internal and external surfaces on the various steel structures (towers and box girders) and specific structural parts placed on e.g. main cables, hangers, cable clamps etc. where the superior element and associated location codes are sufficient for description of the location.

4.2.9 Location Codes

The location of an element and the exact position on a face of the element can be indicated using a maximum of six locations codes, 1 to 6.

Appendix 4.2.E shows for all elements at level 2 - 7 the applicable location codes.

The location codes are:

Code 1: Stationing at start (or at centre of element, e.g. at piers) of the element.

Code 2: Stationing at end of the element.

Code 3: Number/code for the element or part of the element. The present nos. shown on the project drawings for e.g. piers, girder sections, hangers is inserted in the code no. tables to explain the code nos. Most of these numbers can be read on the overall reference drawings appended to section 4.2.10.

Code 4: Orientation of face, e.g. inner/outer (for towers), vertical face to the Right in direction for the stationing (for steel box girders), etc. The faces have whenever applicable been characterised by orientation seen in the direction of the stationing, since this definition always is easy to reconstruct without paying attention to weather conditions.

Code 5: Level, height in meters.

Code 6: Co-ordinates on the face characterised by individual (local) co-ordinate systems to the different elements and whether the co-ordinates shall be used for horizontal, vertical or circular faces.

The location codes are to be used for purpose of inspection and maintenance whenever there is need to describe exact position on a face of an element.

A detailed list of applicable location codes for the individual elements at level 2 - 7 is enclosed as **Appendix 4.2.E.**

4.2.10 Reference Drawings

In the scheme below the connection between the individual elements in the Element Hierarchy and the actual location on the bridge is described, hereunder to be able to locate a possible defect on each single structural part by its element no. and location codes, ref. **Appendix 4.2.E**.

The actual location of the described structural part can be found on the appended drawings to this section.

Structural part to be identified	Reference drawing	Remarks
Main Cables	**Appendix 4.2.F**	The structural part consists of four elements, Main Cable 1 - 4. Main Cable 1 is the western cable and Main Cable 4 is the eastern cable. Individual length of each cable will be noted between the adjacent cable clamps.
Hangers	**Appendix 4.2.G**	The hangers are numbered (x is the hanger no): x.W.N and x.W.S for the two hanger cables in western side, where N is the northern cable. Similar for eastern side, x.E.N and x.E.S, respectively.

Structural part to be identified	Reference drawing	Remarks
Cable Clamps	**Appendix 4.2.G**	The cable clamps to be numbered as the corresponding hangers; x.W.N, x.W.S, x.E.N, x.E.S. **The clamp type C7 and C8 in the side spans must also be numbered, totally 25 clamps at Sicilia side and totally 20 clamps at Calabria side.**
Deck (Steel Box Girders) Diaphragms	**Appendix 4.2.H, I and J** **Appendix 4.2.I and J**	The box girder segments are numbered with the highest number of the two adjacent section nos., e.g. segment 8 is the segment between section no. 7 and 8, ref. **Appendix 4.2.H**. The numbering of the roadway girder segments starts with segment 2 (between section 1 and 2) and ends with segment no. 119 (between section 118 and 119). The numbering of the railway girder starts correspondingly with segment 0 and ends with segment 121. The segment nos. correspond with the hanger nos. A further detailed specification of the location in each of the three box girders can be made by specifying the cell no. between two adjacent diaphragms. The cell nos. are shown on **Appendix 4.2.I** (Roadway Girder) and **Appendix 4.2.J** (Railway Girder). By specification of a specific **diaphragm** the box segment no and diaphragm no. must be specified for the location code 3. The **diaphragms** are numbered for each individual section, starting with no.1 at the northern end of each section, as shown in **Appendix 4.2.I and J.**

Structural part to be identified	Reference drawing	Remarks
		Please notice both type 1 and 2 diaphragms for Railway Girder.
Cross Girder	**Appendix 4.2.K**	The cross girders are numbered with the corresponding section no, see **Appendix 4.2.H**. A further detailed specification of the location can be made by specifying the cell no. between two adjacent diaphragms, see **Appendix 4.2.K** A specific diaphragm in the cross girder can be specified by cross girder no and diaphragm no. as location code 3. Diaphragm no. is shown on **Appendix 4.2.K**
Towers Diaphragms/Stiffener in towers	**Appendix 4.2.L**	The two towers, Sicily and Calabria, are each divided in 21 segments for each leg and 3 cross beams, where Cross Beam 1 is the lower beam and Cross Beam 3 is the upper beam. A further detailed specification of the location can be made by specifying the level and cell no. Each segment is divided in levels (typically 6 levels; L1 - L6) between the transverse diaphragms/stiffeners as shown on **Appendix 4.2.L**. The level is described by location code 5. The cell numbering is also shown on **Appendix 4.2.L** and is described by location code 3. **Diaphragms/stiffeners** are described by - tower - tower leg - segment no. - level no - cell no Segment, level and cell no. is shown on **Appendix 4.2.L** and by location code 4 it can be described whether a defect is on vertical or transverse

Structural part to be identified	**Reference drawing**	**Remarks**
Cross Beams Stiffeners in cross beams	**Appendix 4.2.M**	diaphragm/stiffener. Segment and cell no. is included in location code 3, e.g. 10-4 (segment nr. 10 and cell no. 4) and the level is given by location code 5. The Cross Beams 1 - 3 are each in the Element Hierarchy described by a specific element. By describing the location for defects a further subdivision can be made by adding the cell no. (location code 3) as shown on **Appendix 4.2.M.** The stiffeners in the cross beams are identified by - cross beam no. - stiffener no. (refer **Appendix 4.2.M**) A specific stiffener is given by location code 3, e.g. CB 1 - 3 corresponding to Cross Beam 1 and stiffener no. 3.
Terminal Structures	**Appendix 4.2.N**	The terminal structures are subdivided in separate elements for Sicily and Calabria side. For each side a further subdivision is made in substructures and superstructures. For the substructures, the elements "Foundation" and "Piers" the location could be further detailed by a specific pier no. For the superstructures and the sub-elements "Longitudinal Steel" and "Slab" a further location description (location code 3) for "Longitudinal Steel" would be beam no. and field no for "Slab". Each field is limited by longitudinal beams and gridlines as shown on **Appendix 4.2.N**. As an example, Field no. [(10-11) , (1b - 1c)] is the field on Sicily side limited between beam no. 10 and 11 and the gridlines 1b and 1c, see **Appendix**

Structural part to be identified	Reference drawing	Remarks
		4.2.N. The same location description can be used for bottom plate.
Bearings	**Appendix 4.2.O**	To distinguish between the various bearings for the roadway girders, the bearing type (e.g. A13) and whether the bearing is on the Sicily (S) or Calabria (C) side must be specified for the location code 3, e.g. A13-S. For the railways bearings the bearing type (e.g. A9), eastern (E)/western (W) side of the girder and whether the bearing is on the Sicily (S) or Calabria (C) side must be specified for the location code 3, e.g. A9-W-S. The location of bearings and identification of bearing types is shown on **Appendix 4.2.O**.
Expansion joints	**Appendix 4.2.P**	To distinguish between the various expansion joints for the roadway girders, the joint type (e.g. E6) and whether the joint is on the Sicily (S) or Calabria (C) side must be specified for the location code 3, e.g. E6-S. For the railways expansion joints, the joint type (e.g. E4) and whether the joint is on the Sicily (S) or Calabria (C) side must be specified for the location code 3, e.g. E4-S. The location of expansion joints and type is shown on **Appendix 4.2.P**.
Buffers	**Appendix 4.2.Q** and **Appendix 4.2.R**	For the two buffer types at the towers, the buffer type must be specified supplemented with eastern (E) / western (W) side for the location of the buffer for type D2. To distinguish between the various buffers at the terminal structures, the buffer type (e.g. D3), eastern

Structural part to be identified	Reference drawing	Remarks
		(E)/western (W) side and gridline must be specified for the location code 3, e.g. D3-W-1. The location of buffers and identification of buffer types is shown on **Appendix 4.2.Q** (for the towers) and **Appendix 4.2.R** (for the terminal structures).
Secondary Structures		
Service Lane		Location of defects to be described by stationing (location code 1 and 2).
Wind Screens		Location of defects to be described by stationing (location code 1 and 2).
Roadway Barriers		Location of defects to be described by stationing (location code 1 and 2) and inner/outer side (location code 6).
Tower Gantries		
Main Cable Carriage and Hanger Basket		Location of defect to be described by the following codes (location code 3): - SW Sicily side span, western side - MSSW Main span, Sicily side, western side - MSCW Main span, Calabria side, western side - CW Calabria side span, western side - SE Sicily side span, eastern side - MSSE Main span, Sicily side, eastern side - MSCE Main span, Calabria side, eastern side - CE Calabria side span, eastern side
Gantries for Suspended Deck		

Structural part to be identified	Reference drawing	Remarks
Dehumidification plants	**Appendix 4.2.S**	Each dehumidification plant is specified by a specific number for location code 3, from number 1 to 18. A proposal for numbering of the individual plants is shown at **Appendix 4.2.S**, where the location is shown.
Platform (expression used by the Project for covering both the carriageways and railways) Roadway Railway		 Location of defects to be described by stationing (location code 1 and 2) and lane no. (location code 3). Location of defects to be described by stationing (location code 1 and 2).

All identification numbers must be marked on the individual structures.

4.3 Technological Systems

4.3.1 Element Hierarchy, Level 1

Level 1 of the element hierarchy is assumed to be Messina Link.

4.3.2 Element Hierarchy, Level 2

Level 2 of the element hierarchy is Suspension Bridge.

4.3.3 Element Hierarchy, Level 3

Level 3 of the element hierarchy is Technological Systems.

4.3.4 Element hierarchy, level 4

At level 4 the Technological Systems have been divided into the main elements:

Table 4.2 Element hierarchy, installed elements, levels 1, 2 3 and 4

Element no.					**Description**
L1	**L2**	**L3**	**L4**		**Hierarchy element**
ID	**ID**	**ID**	**ID**	**ID$_{character}$**	
1				**P**	**Messina Link**
	1			**ST**	**Suspension Bridge**
		4			**Technological Systems**
			1	M3	Monitoring Systems
			2	F5	Railway Systems
			3	M2	Mechanical and Hydraulic
			4	E2	Electrical Systems
			5	A3	Safety and Anti-Sabotage Systems (SSS)
			6	M4	Operation and Maintenance Systems
			7	S9	Special Plants

4.3.5 Element Hierarchy, Level 5 and 6

At level 5 and 6 each installation main system has been broken down into sections each categorised by the function or by the purpose of the installation. The level 5 and 6 identification of installation categories are shown below.

Table 4.3 Element hierarchy, Technological Systems, levels 1, 2 3, 4, 5 and 6.

Elements written in black: Level 1 - 4

Elements written in red: Level 5

Elements written in green: Level 6

Element No.							Description
L1	**L2**	**L3**	**L4**	**L5**	**L6**		**Hierarchy element**
ID	**ID**	**ID**	**ID**	**ID**	**ID**	**ID$_{character}$**	
1						**P**	**Messina Link**
	1					**ST**	**Suspension Bridge**
		4					**Technological Systems**
			1			M3	Monitoring Systems
				1		C1	Control & Monitoring System for Electric and Mechanic (EMC)
				2		C2	Railway Monitoring System (RM)
				3		SM	Structural Health Monitoring System (SHMS)
			2			F5	Railway Systems
				1		IS	Signal System
				2		TT	Telecommunication (Railway)
				3		TE	Overhead Electrics
			3			M2	Mechanical and Hydraulic
				1		DI	Water Supply
				2		AS	Surface Drainage
			4			E2	Electrical Systems
				1		SA	Lightning Conductor
				2		DE	Electric Supply MT/ST
				3		SI	Illumination System
					1	IN	Internal Illumination
					2	EX	External Illumination

Element No.							Description
L1	L2	L3	L4	L5	L6		Hierarchy element
ID	ID	ID	ID	ID	ID	$ID_{character}$	
					3	AN	Aviation and Navigation Warning Lights
			5			A3	Safety and Anti-Sabotage Systems (SSS)
			6			M4	Operation and Maintenance Systems
				1		C3	Operational - Logistics MACS (Management and Control System)
				2		C4	DWPMS
				3		C5	WSMS (Work Site Management System)
				4		C6	BMS (WMPS) (Bridge Management System)
				5		C7	ICMS (Information and Coordination Management System)
				6		C8	EDMS (Electronic Document Management System)
				7		C9	CSP (Computing of Simulations and Predictions)
				8		GT	TMS Traffic Management System
			7			S9	Special Plants
				1		SC	Communication System
					1	DS	Data Communication
					2	TC	Telecommunication

4.3.6 Element Hierarchy, Level 7 and 8

Level 7 and 8 are dedicated to define sub-installations, units and items.

4.4 Component Sheets

Component Sheets are being developed for each element of the bridge. The component sheets will be produced for the Structural Elements and the Technological Systems at Level 5 and lower, if necessary, of the Element Hierarchy. The purpose of these sheets is to summarise information relating to the design, supplier, installation and location with further data to guide future inspection and maintenance. Examples of these sheets are provided within **Appendix 4.4.A.**

The component item is defined at the top of each sheet. Each sheet details the relevant design drawings and subcontractor's or manufacturer's drawings are referred to where necessary; all the referenced drawings should form part of the permanent record package. The sheets also detail material items which will be referenced by a code giving a link to details of the product data sheets and supplier contact details as appropriate.

Each Component Sheet will have a unique reference number to allow effective cross referencing. Inspection types and frequencies are summarised on the sheets together with details of the associated Technical Procedures and Technical Instructions.

5 Inspections

5.1 Inspection

This section describes the concept of inspections to be used on the bridge. In principle, three types of inspection are used, Routine, Principal and Special. The nature of an inspection depends upon the manner in which it is to be undertaken, e.g. visual, measurements and testing. The table below sets out the nature of the various types of inspections:

Table 5.1 Nature of the various types of inspections

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">TYPE OF INSPECTION</td></tr>
<tr><td>ROUTINE</td><td>PRINCIPAL</td><td>SPECIAL</td></tr>
<tr><td rowspan="6">Nature of Inspection</td><td>Visual Inspection</td><td>YES</td><td>-</td><td>-</td></tr>
<tr><td>Close Visual</td><td>-</td><td>YES</td><td>YES</td></tr>
<tr><td>Detailed visual</td><td>-</td><td>-</td><td>YES</td></tr>
<tr><td>Functional</td><td>YES</td><td>YES</td><td>-</td></tr>
<tr><td>Non-destructive testing</td><td>-</td><td>-</td><td>YES</td></tr>
<tr><td>Destructive Testing</td><td>-</td><td>-</td><td>YES</td></tr>
</table>

	TYPE OF INSPECTION		
	ROUTINE	PRINCIPAL	SPECIAL
Measurements	YES	YES	YES
Configuration Inspection			YES
Use of monitoring data in Inspection & Maintenance			YES

Policy : It is the aim to ensure by means of appropriate inspection procedures and programmes that all significant defects and deterioration will be detected to enable the structures to be maintained in a sound and safe condition.

The purpose of the Inspection strategy is to allow the changing condition of the bridge elements (in the following in general called "elements" and when necessary distinguished between "structural elements" and "technological systems") to be monitored and understood in a way that will allow maintenance work to be planned and performed at the optimum time to ensure the bridge is kept in a safe, operating condition in an economical manner.

Inspections must be performed by individuals competent to carry out the work. For visual inspections and measurement, an individual's competence to carry out such work shall be based on their experience, training and an assessment of their recent performance. In areas where more detailed inspections are necessary, such as specialist non-destructive testing, e.g. MPI, the assessment of an individual's competence shall also require that he has a recognised and current qualification for the appropriate testing process.

An inspection is classified by its Category, Nature, Frequency, and Scope and these are defined below.

5.2 Inspection Categories

For the purposes of this document, three categories of inspection have been developed, Routine Inspections, Principal Inspections and Special Inspections; these are outlined below but are described in further detail in Sections 5.4, 5.5 and 5.6.

5.2.1 Routine Inspections (R.I.)

Routine Inspections are those inspections which are undertaken with a predefined scope and frequency. This may be, for example, every day for the carriageway envelopes but every two years for the external surfaces of the towers.

They are a general form of inspection seeking to identify obvious deficiencies which might identify a concern that deserves more detailed investigation, (special inspections). This form of inspection will include inspections of plant and machinery at periods proposed by the manufacturers or at periods set by law.

Personnel engaged on the Crossing shall be encouraged to be vigilant and to report anything which appears to need attention. This shall include aspects of overall structural behaviour such as unusual vibrations, noise or deflections.

5.2.2 Principal Inspections (P.I.)

A Principal Inspection is a thorough inspection carried out by experienced Inspectors and undertaken within touching distance of the element being inspected. The frequency of such inspections should not exceed 6 years without careful consideration. Inspection frequency of elements is based on the criticality and vulnerability evaluation described in ref. [2].

Principal Inspections may also involve the use of specialist equipment, e.g. endoscopes for inspecting within restricted spaces or paint thickness gauges for assessing corrosion protection.

5.2.3 Special Inspections (S.I.)

Special inspections are all inspections which are not routine and will generally arise from either defects or anomalies found during Routine or Principal Inspections or arising from accidental damage. Special Inspections may also be required after specified extreme weather conditions and on occasions following a request from the Client for information, surveys or inspections not covered by routine inspections.

Furthermore Special Inspections may also be required based on the criticality and vulnerability evaluation described in ref. [2].

5.3 Nature of Inspections

Within the above three Inspection categories are inspections of varying nature; the nature of these inspections is defined below:

5.3.1 Visual Inspection (V.I.)

The purpose of a Visual Inspection is to determine basic structural condition of all structural members, attachments and coating systems and to identify any missing parts, obvious damage, deterioration or matters which may require further examination. There must be adequate natural or artificial lighting available and binoculars should be used when direct access is not available.

Visual inspection will not require pre-cleaning or special access arrangements and will be carried out during the course of Routine Inspections.

5.3.2 Close Visual Inspection (C.V.I.)

The purpose of a Close Visual Inspection is to determine basic structural condition by visually accounting for all structural members, attachments and coating systems and to identify any obvious damage, deteriorations or areas which may require further examination. All Close Visual Inspections are to be carried out within touching distance of the surface being inspected with adequate natural or artificial lighting.

Inspections for deviations from flatness and straightness may be carried out by sighting along the members or parts to judge the magnitude of any deformation. Where the magnitude appears to constitute a defect the deviation shall be determined accurately by measurement and recorded for future reference.

Pre-cleaning will not normally be necessary but special access arrangements will be essential for many elements and protective covers or shrouds will have to be removed.

5.3.3 Detailed Visual Inspection (D.V.I.)

The purpose of a Detailed Visual Inspection is to detect by visual means using magnification or endoscope where appropriate any significant surface defects, deteriorations or areas which may require further examinations. All Detailed Visual Inspections are to be carried out within 300 mm of the surface being inspected. There must be adequate natural or artificial lighting available.

Pre-cleaning to bare metal will normally be required. Special access will be essential for most elements and seals. Protective covers and shrouds will have to be removed.

5.3.4 Functional Inspection (F.I.)

A functional inspection consists of checking that mechanical and electrical plant and equipment function in accordance with the relevant provisions of this Manual and the relevant Manufacturer's Operating Manual. Functional Inspection activities may include some degree of preventative maintenance e.g. checking and adjusting oil and water levels, tyre pressures etc.

5.3.5 Non-Destructive Testing (N.D.T.)

It may sometimes be desirable to supplement visual Inspections with non-destructive testing techniques such as:

Tapping of concrete or steel surfaces with a light hammer to detect, by the 'ring', whether lamination has occurred or bolted connections have lost tightness.

In Special Inspections non-destructive testing using ultrasonic, magnetic particle, radiographic and other appropriate equipment shall be used where relevant and necessary to determine the nature and extent of a defect.

5.3.6 Destructive Testing (D.T.)

Destructive testing requiring removal of any part of the structure may be necessary to determine the cause of an identified defect. **No such testing shall be undertaken without the prior review by Stretto di Messina of the specific work in each instance.** A written method statement, unique to each particular activity of destructive testing shall be prepared and written.

5.3.7 Measurements (MEAS.)

It may sometimes be necessary or desirable to supplement inspections with measurements. For example:

- Measurement of the surface gap width of any wide cracks (e.g. concrete cracks which are wider than 0.25mm or wear in bearings and joints).

- Fixing of tell-tales where the continued opening of cracks in concrete structures is suspected.
- Use of paint thickness gauge when examining the protective system.
- Measurement of defect size.
- Measurement of wear.
- Measurement of bolt tension.
- Strain Gauging.
- Electrochemical potential.
- Chloride profiles.

5.3.8 Configuration Inspection

Configuration inspections/movements surveys shall be carried out once every two years, or when required after any seismic event. The monitoring/survey points to be checked during each survey shall be agreed with SdM prior to commencement of the survey. The inspection/survey shall be carried out under the supervision of a Registered Professional Surveyor (Land Surveying), who should have sufficient local knowledge and experience. An engineer experienced in the structural behaviour of suspension bridges shall advise on the timing and weather conditions of the inspections and review the survey results and those of previous surveys. The review shall include but not be limited to checking the tower verticality, the alignment, profile and displacement of the main components of the Messina Strait Bridge, e.g. for registration of horizontal movements of anchor blocks and relaxation of the main cables. Within 2 months following completion of the survey, a report must be submitted to SdM incorporating the results of the survey, the review and recommendations on any problems or abnormalities found.

5.3.9 Use of monitoring data in Inspection & Maintenance

One of the objectives of the Structural Health Monitoring System, SHMS, is to provide current information on the behavior and condition of structural elements.

Monitoring data to be used in Inspection & Maintenance activities consists of two parts:

- Data to supplement information from inspections.

- "Stand alone" information related to behavior of structural elements.

Data to supplement inspections, raw data or data processed in the Computing of Simulations and Predictions (CSP), Sub-system of Management, Maintenance and Simulations System (MMS), will be incorporated in the Inspection Reports. Data will be used in the evaluation of the condition rating of the structural element. The type of inspection will be Special Inspection, ref. to section 5.2.3.
Monitoring can for instance replace comprehensive and complex inspections or supplement inspection observations with video camera records

Examples of "stand alone" data are stress fluctuations for fatigue analysis and joint movement data for joint movement review. These data may be processed further in the CSP Sub-system of MMS. Results can be presented either in reports generated in CSP or in Special Inspection Reports generated in Bridge Management System (BMS). In the latter case the report will normally include results from other related inspections and evaluations.

SHMS itself generates various types of simple data reports - weekly, monthly and yearly reports. Moreover a report is generated immediately after a seismic event. A number of other reports for SHMS function shall be created automatically or at request. It is anticipated that a series of 'thresholds' will be developed within SHMS to alert inspection and maintenance managers to the severity of reaction of particular components to seismic or other extreme events. Such thresholds may indicate whether initial response to such events justify complete closure and evacuation of the crossing or restrictions of use.

The reports include presentation of monitoring data related to various subjects: seismic, fatigue, displacements etc.

The CSP system extracts data from the SHMS database and processes the data to generate results for further use in operation and maintenance of the bridge. Examples are curves showing traffic loads in a period, expansion joint movements in a period and stress variations in a period. CSP can generate reports for presentation of the processed results. For this CSP uses the report generation facilities provided in Management and Control System (MACS). In this way the CSP carries out a simulation and prediction oriented evaluation of the registrations captured by SHMS.

The Inspection & Maintenance Organization receives its monitoring data through the CSP facility. This comprises intelligent data as deflection curves and peak stress values as well as simple illustrations, in pdf-format for example.

In this way monitoring data, primary data as well as processed (monitoring) data, is used as inspection data in management of inspection and maintenance. Data created with the CSP function will, directly or as further processed, be incorporated into reports generated by I & M by use of the BMS. In this way BMS carries out an inspection and maintenance oriented evaluation of the registrations captured by SHMS.

The Inspection & Maintenance Organization will by use of BMS carry out a review of the trigger values used in SHMS using monitoring data provided via the CSP function. If a trigger value is to be changed the I & M Organization will report this immediately to SHMS.

5.4 Routine Inspections

As stated above, Routine Inspections are those inspections which are undertaken with a predefined scope and frequency. They are a general form of inspection seeking to identify obvious deficiencies which might lead to risk or deserve more detailed investigation by instigating a Special Inspection. Routine inspections are of the following types:

5.4.1 Routine Superficial Inspections (R.I.)

These are Visual Inspections (V.I.) of carriageways and of structures at or above deck level to detect any defects, damage or debris which may present hazards or deserve special inspections. They shall include inspections of drainage, barriers, surfacing, signs and road markings. Such inspections can be carried out from a slow moving vehicle on the carriageway or service lane, making stops as necessary for closer inspection, e.g. by use of binoculars.

5.4.2 Routine Statutory Inspections (Stat.)

These are inspections required by law to be undertaken in the manner prescribed in the relevant Statutes. The inspections will apply to walkways, ladders, platforms and other access facilities, lifts, gantries, compressed air, water and electrical services. A register of the requisite statutory inspections shall be drawn up and maintained. The inspections shall be carried out by competent personnel in the manner prescribed by the relevant Statutes in force at any time.

5.4.3 Routine Functional Inspections (F.I.)

These are inspections of lifts, gantries, compressed air and water services, lighting, electrical services, signs, navigation lights, foghorns and local heating systems required by the relevant, associated manufacturers' manuals or other relevant directives. A register of the requisite functional inspections shall be drawn up and maintained.

5.4.4 Routine General Inspections (G.I.)

These are those inspections required by the Inspection Programme (Refer to **Section 11**). Such inspections shall be undertaken in the manner described in the associated Technical Instructions. These inspections may be Close Visual Inspections **(C.V.I.),** Visual Inspections **(V.I.)** or, where it is otherwise necessary to record the extent of wear or magnitude of a defect, measurements **(MEAS.)** are to be made

The Technical Instruction documents for the various bridge parts will specify the most appropriate type of Routine Inspection that should be applied to each part.

5.5 Principal Inspections (P.I.)

As stated above, a Principal Inspection is a thorough inspection carried out by experienced Inspectors and undertaken within touching distance of the element being inspected, i.e. a Principal Inspection is a Close Visual Inspection.

Principal Inspections should be undertaken using the best available access method. Where maintenance gantries are available for specific parts, these gantries should be used. Any inaccessible areas should be noted and recommended for a follow-up Special Inspection.

Principal Inspections may also include other types of inspection and involve the use of specialist equipment, e.g. endoscopes for inspecting within restricted spaces (D.V.I.) or paint thickness gauges for assessing corrosion protection (MEAS). A Technical Procedure for performing Principal Inspection is developed, refer section 5.10.1.

5.6 Special Inspections (S.I.)

As stated above, Special Inspections are all inspections which are not routine and will generally arise from either defects or anomalies found during Routine or Principal Inspections or arising from accidental damage, e.g. traffic incidents. Special Inspections may also be required after specified extreme weather conditions and on occasions following a request from the Client for information, surveys or inspections not covered by routine inspections.

The primary purpose of a Special Inspection is to ensure that the cause of a defect is known and understood, to assess the effect that a defect may have on other elements and to assist with the development of an appropriate monitoring or repair strategy to deal with the defect.

The nature of inspections carried out during Special Inspections shall be appropriate to the circumstances and could include any of those listed in **Section 5.3** above. It may comprise a close visual inspection, testing and/or monitoring and may involve a one-off inspection or an ongoing programme of inspections, i.e. Special Inspections are tailored to specific needs. Appropriate Technical Instructions for effectively investigating such defects will need to be developed to suit individual cases; this may also include reference to historical records, e.g. construction records, traffic video monitoring records.

Special Inspections may be considered to fall into four types:

- Type A – As a supplement to a Routine or Principal Inspection where closer access, special equipment or knowledge is required to provide or interpret observations. This would include the opening up of areas not included in the scope of the Principal Inspection, e.g. removal of shrouds or covers to allow a detailed inspection of a main cable. Client requests for additional investigations or surveys would be included as Type A.

- Type B – Detailed investigation to identify extent, cause and effect of an identified defect. This will include development of possible repair actions and providing cost breakdowns for suggested repairs. Will also assess need for additional inspection of other areas where the reported defect may also develop.

  Examples of Special Inspection Type B:

  - Investigation of fatigue cracking in stiffening girder
  - Repair action resulting from a traffic incident
  - Structural elements exposed to abnormal heavy load.

- Type C – Function Investigation, i.e. targeted inspections of areas potentially affected by an event such as extreme weather, abnormal load movement or immediately following impact from traffic incidents.
- Type D – Monitoring, i.e. where a decision has been made for a known defect or area to be monitored to provide further information of the cause of the defect and the effect of that defect. Once the monitoring system has been established, further associated Inspection can be planned and programmed.

  Examples of Special Inspection Type D:

  - Measurement of foreseen or unforeseen settlements of structures
  - Fatigue in hangers and stiffening girder
  - Environmental monitoring on suspension bridge
  - Control of groundwater level or change in groundwater level.

5.7 Inspection Frequencies and Timings

5.7.1 Routine Inspections (R.I.)

The various types of inspection described in **Section 5.4** are to be undertaken at the following frequencies and timings.

Routine Superficial Inspections: These shall be undertaken at regular intervals, e.g. carriageway inspection by driving over the bridge once per day or weekly inspection of expansion joints.

Routine Statutory Inspections: These shall be undertaken at frequencies and times prescribed by the relevant Statutes.

Routine Functional Inspection: These shall be undertaken at frequencies and times prescribed in the relevant Manufacturer's Operations and Maintenance Manual or directives.

Routine General Inspections: These are to be undertaken at frequencies related to structural criticality and vulnerability to damage, wear and corrosion. The frequencies of such inspections shall vary from part to part throughout the life of the structure. Frequencies for each bridge part will be stated in the Technical Procedure and Instruction and typically will initially range from every 6 months to every 2 years.

5.7.2 Principal Inspections (P.I.)

The frequency of principal inspections should not exceed 6 years without careful consideration.

Based on performed Failure Mode, Effects and Criticality Analysis (FMECA) and Inspection and Maintenance Activities Analysis (IMAA) in report for Reliability Based Inspection (RBI) and Reliability Centred Maintenance (RCM) [2] the frequency for principal inspections for various elements is evaluated.

For some of the elements there may be economical benefits in making detailed inspection plans based on either RBI or RCM in order to reduce the extent of inspections. The difference between RCM and RBI is defined as:

- RBI applies for systems with predictable failure patterns where there is a sound condition indicator/parameter available, i.e. where the rate of deterioration of an element can be measured over time and an assessment made of the date when repair, replacement or renewal is expected. Furthermore, the time for failure development shall be larger than the inspection interval.
  For example, external surfaces of the bridge girders can be inspected to monitor the rate of deterioration of the corrosion protection system and to determine the expected time before repainting of the top coat is necessary.

- RCM applies for systems with predictable failure patterns where there is no condition indicator/parameter available or the time for failure is less then the inspection interval. Such elements (called systems in [2]) are often mechanical, hydraulic, and/or electrical in nature.

It can be seen from the above that RBI would be suitable for several structural elements, particularly for parts which are difficult to access or where they are extensive and repetitive. When establishing an RBI plan it requires a sound condition indicator that describes the degradation process. This condition indicator shall be chosen so that it can be determined with the highest possible accuracy during inspection, i.e. measurements may be advantageous to engineering judgement. The condition indicator could be established based on codes, standards or scientific references.

Furthermore, RBI planning requires a threshold value in the same format as the condition indicator. The threshold value determines the estimated service life of the degrading element (e.g. protective system), i.e. the threshold value is an acceptance criteria. The threshold value may be changed due to Life Cycle Cost Study or other operational circumstances.

Reliability Based Inspection Plan for renewal of topcoat on the suspended deck and towers.
In the Reliability Based Inspection (RBI) and Reliability Centred Maintenance (RCM) report [2] a reliability based inspection plan is made for renewal of topcoat on the painted areas of the main structural steelwork elements (bridge girders and towers).

Extent of inspection

The initial RBI plan is based on an estimate of expected service life (derived from experience), vulnerability derived from FMECA and by setting the parameters as described in [2].

The expected service life of the topcoat is 30 years.

Special inspection plan

Based on vulnerability derived from the FMECA analysis the intervals between special inspections are set to 6 years. The actual coating condition values measured during these inspections will become the background data for estimating the actual service life of the top coat.

These special inspections are performed on three to five carefully selected representative areas on the suspended deck and towers respectively, where close visual inspection (CVI) of all coated areas will be performed and evaluated with a Coating Condition indicator, CC. An example of assessment of coating condition based on closed visual inspection is shown in Appendix E1 in [2]. All other bridge areas will be inspected less thoroughly, but sufficient to find large deviations from the condition of the selected representative areas.

Principal inspection plan

The time for the first necessary reliability based principal inspection of all painted areas is calculated to be in year 27.

Routine superficial inspection plan

A periodic visual (V.I) routine superficial inspection (R.I.) will be performed together with the special inspections mentioned above where all segments will be inspected visually, just close enough to find significant deviations from the representative bridge sections, where the special inspections are performed.

When selecting the reference areas it is important to include vulnerable areas containing (in random order):

- Areas painted on-site due to site welding or bolting during construction phase.
- Areas where design changes during construction phase have been made.
- Most difficult areas from a workmanship point of view
- Prone areas identified warranty inspection
- Areas subjected to mechanical wear from e.g. inspection gantries, access points.
- Areas subjected to UV-light
- Areas facing the prevailing wind
- Those areas that are most vulnerable due to corrosion (bolts and high stress welds).

The Technical Manager will be responsible for updating of the reliability based inspection plan.

5.7.3 Special Inspections (S.I.)

Special Inspections with CVI shall be carried out on certain parts following incidents of very high winds, extreme temperatures or seismic activity. Structural Health Monitoring System (SHM) will have warning and alarm thresholds for structural elements that will identify locations and periods of excessive movements, vibrations or change of relative humidity etc. Special Inspections will be undertaken in response to such indications from the SHM systems. In some such instances the Operations Manual may advise that the bridge should be closed to all traffic until such inspections have been completed and no defects reported. In such scenarios the amount of inspection may be significant and as such the bridge would remain closed for some time. The Operations Manual should be aware of this and include an estimate of inspection time required. Also note that following such incidents the availability of staff to undertake such inspections may be limited.

The details of such inspections will need to be developed.

Operational events, such as road traffic incidents that have caused a degree of damage to the bridge parts, will instigate a Special Inspection. Such an inspection will initially assess whether structural damage has occurred and whether operational safety has been reduced. Subsequent Special Inspections may be required.

Other Special Inspections shall be undertaken promptly following the detection of a defect or anomaly considered to be potentially critical; particularly if the cause of the defect or anomaly is not identified or understood.

Monitoring inspections resulting from Special Inspections shall be undertaken at frequencies dependent on the nature of a defect and are to be agreed with SdM.

As noted in Section 5.7.2 above, Reliability Based Inspections plans may also require Special Inspections to be undertaken on selected, representative sample areas.

5.7.4 Timing of Inspection

Where specialist access equipment is utilised to undertake work on the bridge; for example, if a main cable gantry is erected to investigate or repair a dehumidifying element on the main cable, serious consideration should be given to taking full advantage of this to inspect other parts that would not otherwise be so accessible. In this example, elements of the main cable system could be subjected to a close visual inspection.

Similarly, when access to a cable anchorage is arranged for an inspection of the main cable elements, inspection of the access stairs and platforms could be added to the scope of that inspection. Such an inspection may not be due at that time but its inclusion may be more cost effective than undertaking it separately at a later time.

The checking of moving parts for vibration or noisy operation is to be timed to coincide with high loading conditions and/or rapid cyclic loading as appropriate. Therefore it will be necessary to arrange such inspections at short notice as the conditions occur.

5.8 Inspection Programmes

The Technical Manager shall prepare or shall cause the preparation of formal Inspection Programmes covering all Routine and Principal Inspections. All inspection programmes shall be independent of the Routine Maintenance Programmes, however the maintenance programmes may coordinate with the inspection work. They shall define the Nature (**Section 5.3)**, Category (**Section 5.2**) and Frequency (**Section 5.7**) of each inspection.

5.9 Competence of Inspection Staff

All maintenance inspections must be undertaken by personnel that are judged by the Technical Manager to satisfy the minimum health, experience and, where appropriate, qualification requirements for the particular inspection type and scope. In-house inspection staff should be competent to carry out all Routine Inspections and the majority, if not all, of the Principal Inspections. It should be expected that in some cases, Special Inspections may require input from specialist personnel and specialist companies.

Inspection staff will sourced from a variety of backgrounds, e.g. structural, mechanical or electrical. The Technical Manager will encourage suitable 'cross-training' of inspectors to ensure that inspection teams can be capable and vigilant in recognising and reporting potential concerns in elements throughout the structure.

The Technical Manager will continually review the performance of the Inspection personnel and address any areas of concern. This may involve additional training, a change of duties or disciplinary action.

Concerning qualification, information and training of inspection personnel, see section 9.3.2 and 9.3.3.

The Technical Manager will establish a procedure, common to all maintenance inspections, whereby inspection staff have a clearly defined duty to inform the Technical Manager or designated staff, at the earliest opportunity, of any defect that may represent an immediate risk to public safety and/or structural stability.

5.10 Technical Procedures and Instructions for Inspection

5.10.1 Structural Inspections

There shall be formal inspection procedures for Routine and Principal Inspections of all structural parts. The scope of each inspection shall be defined within its associated Technical Procedure and Instruction.

Some of the Technical Procedures and Instructions will be dealing with both inspection and maintenance, typically for mechanical bridge elements, where functional inspections are necessary. Functional Inspection is typically an inspection for both the elements function and may include preventative maintenance of the element.

TECHNICAL PROCEDURES

The purpose of a Technical Procedure (TP) is to set out detail and background to a major element of the structural system. (Procedures for the Bridge cable suspension system and Steel structures are developed as examples of major elements). The Technical Procedure will relate to a number of elements and each or groups of these elements will have an associated Technical Instruction. The TP will give reference to the construction specification and to material data sheets and other information of the parts within the element covered by the TP. The requirement for Routine and Principal Inspections shall be stated together with a list of potential Special Inspection requirements.

Included within the Technical Procedure documents will be a section identifying potential corrective maintenance activities associated with the elements covered by the procedure. Such activities would include work such as remedial painting, weld repairs, patch repairs to sheathing, crash barrier repair/replacement etc. In cases where a Technical Procedure does not describe the method of repair, consideration should be given to preparation of appropriate method statements at the appropriate time to ensure that such remedial work can proceed without delay.

As mentioned above Technical Procedures for the Bridge cable suspension system and Steel structures are developed and appended as **Appendix 5.10.A and Appendix 5.10.B,** respectively.

A Technical Procedure for Principal Inspection has been developed and is appended as **Appendix 5.10.C.** The Procedure includes description of how inspections are to be undertaken and how inspections are to be recorded and reported.

The Technical Procedure is also considering the topics

- Defect Type Categories
- Defect Extent and Severity Ratings (Condition Ratings)
- Recording and Logging Procedures

TECHNICAL INSTRUCTIONS

The purpose of the Technical Instructions (TI) is to set out to the associated inspectors a short description of the elements to be inspected together with details of the inspection work required and, where appropriate, details of the defects likely to occur to that element. Inspectors will be expected to review previous inspection reports for the elements to be inspected and encouraged to seek discussion with the previous inspection team whenever possible. In this way the inspection staff are made aware of the reason for the inspection and are thus more likely to be better motivated when undertaking the task. A Technical Instruction will be targeted towards a number of bridge parts which are best being inspected as a group rather than as individual parts and will list out any special equipment that may be needed for the inspection. An annex to a TI will include reference proforma and associated sketches.

As an example, Technical Instructions (TI) for parts of the Bridge cable suspension system and Steel structures related to the above Technical Procedures have been developed and are appended.

- TI covering (appended as **Appendix 5.10.D**) and related to Bridge cable suspension system, external main cable elements:
  - Main suspension cables (for the length between anchorage entry points).
  - Handstrand ropes (including anchorage points and associated support posts).
  - Cable Clamps (including bolts and seals).

- Hangers (including sockets, pins, bearings, dampers and bend limiters fitted to hangers).

• TI covering (appended as **Appendix 5.10.E)** and related to Bridge cable suspension system, main cable elements within the anchorage chambers:

- Main suspension cables in anchorages (for the length from anchorage entry points)
- Splay saddle
- Anchor rods, plates and bolts

• TI covering (appended as **Appendix 5.10.F**) and related to Steel Bridge Structures, internal elements of steel road girders, steel rail girder and steel cross girders:

- Steel box girder (Carriageway West and East) internal surfaces and troughs below deck plate
- Steel box girder (Railway) internal surfaces and stiffeners below deck plate
- Steel box cross girders internal surfaces

• TI covering (appended as **Appendix 5.10.G)** and related to Steel Bridge Structures, external elements of steel road girders, steel rail girder and steel cross girders**:**

- Steel box girder, (Carriageway West and East) external surfaces with cantilever.
- Steel box girder, (Railway) external surfaces.
- Steel box cross girders, external surfaces.

A TI for Inspection of Crash Barriers has been developed and is appended as **Appendix 5.10.H**

Finally a TI for Instruction of Reporting (**Appendix 5.10.I**) related to TP for Principal Inspection has been developed.

5.10.2 Inspections of Mechanical and Electrical Installations

It is anticipated that mechanical and electrical installations will have associated inspection and maintenance manuals provided by the suppliers/manufactures. It is these documents, as the recommendations from the suppliers and manufactures, and performed Failure Mode, Effect and

Criticality Analysis (FMECA) and Inspection and Maintenance Activity Analysis (IMAA) that initially will determine the inspection and maintenance requirements for these elements. Operation and Maintenance Manuals for each item of equipment will be available to the inspection staff and will be included as appendices to this manual.

Detailed FMECA and IMAA are elaborated and enclosed in Appendix C in [2] for

- Roadway expansion joints
- Railway expansion joints
- Dehumidification system for main cables
- Structural Health Monitoring System (SHMS)

5.10.3 List of TP's and TI's

In **Appendix 5.10.J** the actual list up to now of identified Technical Procedures and Technical Instructions to be made is shown.

The list includes identified Procedures and Instructions for both inspection and maintenance, refer section 5.11 and 6.8, respectively.

Furthermore it is shown in **Appendix 5.10.J** whether the procedures and instructions have been carried out during Progretto Definitivo or will be carried out during/after the construction phase. The documents carried out during Progretto Definitivo will need a review during/after the construction phase.

The majority of procedures and instructions is recommended to be carried out during/after the construction phase primarily due to their dependency to instructions and maintenance manuals to be submitted from the selected supplier/manufacturer.

For many of the technological systems, refer section 12, and structural elements like bearings, expansion joints and buffers this will be the case. When the elements are installed and the suppliers/manufacturers detailed instructions and maintenance manuals are delivered a detailed going through must be performed of the instructions and manuals and based on those relevant technical procedures and instructions must be carried out.

5.11 Contents of Inspections

In the following sections examples of topics for various structures and installations are mentioned which will require technical procedures and instructions to be prepared.

The list of mentioned topics is not complete and some structural elements and installations are not mentioned.

5.11.1 Steel Structures, girders and towers

Description of inspections to be performed is described in attached example of Technical Procedure and Technical Instructions (only covering the girders), see **Appendix 5.10.B** and **Appendix 5.10.F + G.**

For the towers special attention during the inspections must be paid to the most structurally utilised parts of the structure:

- The connections between the cross beams and tower legs due to tension primarily. However, the degree of concern has to be evaluated when the prefabricated crossbeams are welded to the tower legs and a judgement made of how the tolerances were met.
- The tower base holding down bolts, which have to be watched for any de-tensioning.

In case of earthquake an inspection of the areas mentioned above must be performed plus the tower leg sections above and below the cross beams. Inspections should look for any signs of distress at connections, e.g. cracked paint (often at edges between plies of steel or at fasteners), and any noticeable change in smoothness of the steel panels, i.e. to look for any signs of buckling or distortion.

5.11.2 Bridge cable suspension system

Description of inspections to be performed is described in attached example of Technical Procedure and Technical Instruction, see **Appendix 5.10.A and 5.10.D + E.**

5.11.3 Carriageway surfacing

On yearly basis the following inspections are recommended for the carriageway surfacing:

- Visual Inspection recording damages and defects on the surfacing and adjoining items as joints, road marking and crash barriers.

  The inspection must also include evaluation of former repairs.

  The inspection is recommended to be carried out in the spring.

  The inspection will normally be performed in front of a TMA (truck mounted attenuator) vehicle in the "heavy" lane, this TMA vehicle will provide protection to the site staff.

- Once a year it is recommended to measure the skid resistance. The vehicle to do the measurements must be fitted with equipment, which is capable to make the measurements according to International friction index.

  Besides measurements on a randomized basis measurements should also be made on reference areas.

  A Roughness Pendulum can be used as additional or alternative method.

- Every 6 years a Principal Inspection must be carried out including inspection of all lanes and may include the taking of samples.

  A high voltage "Holiday" detector may be used if damage and especially cracks have occurred. Such equipment will be able to detect whether the damage is going through to the steel deck.

  The inspection will normally be performed in front of a TMA vehicle in the "heavy" lane.

- Video surveillance from car can be used as a supplement to the yearly visual inspection. The benefit of video surveillance is that the evaluation can be done at any time after the video has been recorded.

In case of weld repair to the underside of the deck plate an inspection of the associated surfacing above must be undertaken while it is anticipated that a repair to the surfacing should be undertaken within the following twelve months.

5.11.4 Bearings

The supplier of the bearings is still not known.

It is expected that the majority of bearings will be spherical ones and for that type of bearings the inspections must cover among other things:

- dirt accumulation
- general condition with regard to corrosion
- any rust discolouring from fissures
- dust protection incl. windscreen
- stainless sliding plate, surface, scratches, dirt
- stainless sliding plate, smoothness (dents or deformations may occur due to high friction)
- stainless sliding plate for guide rail, deformations, scratches
- condition of welds and bolts
- grouting, cracks, spalling
- adjacent structural parts, cracks in concrete, condition of paint
- measurement of the rotation of the bearing
- measurement of the open joint (for measurement of the wear of the teflon plate with an accuracy of 1/10 mm)
- cleaning of bearing before assembling of dust protection
- measuring of bearing position

There may be other items to be inspected depending on the chosen bearing supplier.

Measurements of rotation and the open joint must be compared with the reference measurements. A minimum size of the open joint must be determined based on recommendation of the supplier.

Due to the large accumulated horizontal movements primarily due to the train traffic it is recommended to be aware of the rate of wear of the horizontal teflon plates by frequent measurements.

5.11.5 Expansion Joints

5.11.5.1 Roadway Expansion Joints

The experience with large expansion joints has shown that inspection and maintenance of the joints is required from the beginning, especially hand-over inspections, in order to catch various construction faults to be repaired by the warranty obligations of the contractor/supplier.

It is important that the supplier provides a detailed Inspection and Maintenance Manual including method statements for replacement of the replaceable parts and replacement of the joint as a unit (or parts in order to maintain the traffic on the bridge).

The supplier of the expansion joint is still not known, but in general terms it is expected that inspections must cover.

- Tightening strips to be inspected among other things for
  - dirt accumulation
  - mechanical damage
  - correct mounting / loose strips
  - water tightness
- Sliding surfaces and sliding parts (e.g. springs and especially control springs) to be inspected among other things for
  - wear
  - damage of sliding surfaces
  - defects / correct position / correct prestressing
  - unusual noise

- Inspection of corrosion protection
- Load carrying structures to be inspected among other things for
  - Whether the moveable parts have the necessary freedom of movement
  - The anchorage of the joint to the adjacent structures
- Inspection of the surfacing close up to the expansion joints for defects

The accessibility for inspection of the expansion joints from below is best at low temperature.

Inspections recommended, based on the vulnerability classification in [2], are shown in Table 5.1.

Table 5.1 Assessment of inspection type and interval for the roadway expansion joints, using vulnerability classification as a guideline.

Where?	What?	Principal inspection		Routine inspection	
		Frequency	Extent	Frequency	Extent
Expansion joint top (from carriageway)	Steel lamellas and sealing strips.	3 Months	100%	Weekly	100%
Expansion joint bottom (from access platform)	All parts	yearly	100%	None	None

Due to the large expansion joints and the amount of expected movement it is important to measure and record the amount of wear of the moving parts.

A strong indicator of whether the expansion joints operate unsatisfactory is unusual noise. In case of such noise a special inspection must be performed in order to identify the cause.

A stock of appropriate spare parts for the expansion joints should be established for the components which are most likely to need replacement, which usually are the tightening strips and the elastic neoprene components. Development of a reasonable stock must rely on recommendations from the supplier, who, according to the present version (under development) of the Performance Specification, shall provide spare parts for the first 5 years of operation in accordance with the suppliers' maintenance manual.

5.11.5.2 Railway Expansion Joints

The experience with large railway expansion joints has shown that inspection and maintenance of the joints is required from the beginning.

According to "Performance Specification - Rail Expansion Joints" [6] the manufacturer must, among other things:

- Submit his recommended maintenance regime for the first year of normal railway operation
- Throughout the maintenance period attend all maintenance operations and, in conjunction with the railway operator, monitor the performance of the railway expansion joints by carrying out quarterly surveys and submit reports similar to the pre-completion survey and report.
- If a defect, sufficient to affect normal railway operations, is found, the manufacturer shall forthwith effect such repair or replacement as may be necessary.

The manufacturer must submit an Operation and Maintenance Manual; a list of contents for the manual is described in the performance specifications [6].

From the commencement of normal railway operations a sufficient number of railway operator's maintenance staff must be fully trained and become capable of maintaining, repairing and replacing the railway expansion joints or any component parts. This training is also a part of the manufacturer's obligations.

The manufacturer of the expansion joint is still not known and therefore the actual type of expansion joint is also unknown, but in general terms it is expected that inspections must cover:

- Sliding surfaces and sliding parts to be inspected among other things for
  - wear
  - slackness
  - damage of sliding surfaces
  - defects / correct position
  - unusual noise
  - sufficient cleaning

- Inspection of the functionality of the equalizer system. The equalizer system assures the constant distance between the sledges.
- Inspection of corrosion protection
- Load carrying structures to be inspected to ensure that the moveable parts have the necessary freedom of movement
- Inspection of the electrical continuity of the running rails across the expansion joint with the adjoining track
- Inspection of provisions to eliminate stray current corrosion

After the maintenance period is expired an evaluation of the frequency of routine inspections must be done.

The performed Failure Mode, Effect and Criticality Analysis (FMECA) in [2] proposes several different inspection intervals for the various parts of the joint, based on vulnerability classification, however all parts are critical and therefore it is recommended that the joint, as a whole, is inspected with the same interval. See Table 5.2.

Table 5.2 Assessment of inspection type and interval for the railway expansion joints, using vulnerability classification as a guideline.

Where?	What?	Principal inspection		Routine inspection	
		Frequency	Extent	Frequency	Extent
Railway expansion joint (from above and from access platform)	All parts.	6 Months	100%	Weekly	100%

Due to the large expansion joints and the amount of expected movement, it is important to measure and record the amount of wear of the moving parts.

Another strong indicator of whether the expansion joints are operating satisfactorily is unusual noise. In case of such noise a special inspection must performed in order to identify the cause.

According to the performance specifications [6] the manufacturer shall

- bring sufficient replacement parts to site to ensure that should any part of the railway expansion joint fail at any time from completion of installation to the end of the maintenance period a replacement part is immediately available
- prepare a list of recommended replacements parts during the maintenance period in sufficient time for them to be supplied to the railway operator before the expiry of the maintenance period
- supply any special tools which may be necessary for maintenance or replacement of the railway expansion joints

5.11.6 Hydraulic Buffers

For the hydraulic buffers

- D1 at the towers, see **Appendix 4.2.Q**, and D3 and D4 at the piers for the Terminal Structures, **see Appendix 4.2.R,** which are installed for energy absorbing in case of earthquake.
- D2 at the towers, see **Appendix 4.2.Q**, which are installed to reduce the longitudinal movements of the girders by transferring load to a certain limit from the road girders to the towers and thereby reduce the longitudinal movements caused by temperature changes and traffic. The buffers act as over-press valves and dampers and reduce the free movement of the suspended deck significant.

various inspections have to be carried out:

- Service inspection every 2 months by Inspection and Maintenance Organization's own skilled personnel. The service inspection is a function test of the buffers.
- Routine inspection every 6 months carried out by a service contractor.
- Principal inspection every year based on Failure Mode, Effects and Criticality Analysis (FMECA) and Inspection Maintenance Activities Analysis (IMAA), refer Appendix C in [2].

The content of the inspections are briefly described in **Appendix 5.11.A** inclusive requirements to the coming operation and maintenance manual to be provided by the supplier.

5.11.7 Access Facilities - Moveable

The moveable access facilities

- Gantries for suspended deck
- Gantries for towers
- Lifts
- Main cable carriage & hanger basket.

Components to be checked are described in **Appendix 5.11.B**, but the intervals for the various parts to be determined by Failure Mode, Effects and Criticality Analysis (FMECA) and Inspection Maintenance Activities Analysis (IMAA) together with the suppliers' recommendations.

5.11.8 Dehumidification System

Several structures on the bridge:

- Anchor blocks.
- Main Cables and Saddles.
- Suspended deck structures and steel Terminal Structures.
- Towers.

are dehumidified in order to keep the relative humidity at an acceptable low level to prevent corrosion.

Various inspections have to be carried out for the dehumidification plants:

- Functional inspection every 2 months by the Inspection and Maintenance Organization's own skilled personnel.
- Routine inspection every year carried out by a service contractor.

In [2] a Failure Mode, Effect and Criticality Analysis (FMECA) and Inspection and Maintenance Activity Analysis (IMAA) has been performed for the dehumidification system. Depending of the consequences of failure of various components of the system related to a fully operating dehumidification system the analysis recommends continuous monitoring with principal inspection or evaluation of monitoring data at intervals between 6 months and 6 years dependent on the level of criticality. Please refer to Appendix C in [2] for details.

The content of the inspections are briefly described in **Appendix 5.11.C** inclusive requirements to the coming inspection and maintenance manual to be provided by the supplier.

6 Maintenance and Spare Parts

6.1 Inspection and Maintenance Objectives

It is an objective of inspection and maintenance to preserve the integrity and safety of the structure while carrying the anticipated loads. For certain parts subject to wear or anticipated limited life (such as wearing parts, bearings and surfacing) maintenance shall include replacement of parts.

Policy: The aims of maintenance are:

- by preventative action to limit deterioration or malfunctioning of parts and equipment to safe and economical levels
- by replacement of worn parts to ensure continuity of desired performance
- by remedying recorded defects with the degree of urgency indicated by the specific Maintenance Manuals, RBI/RCM plans, standards, guides or severity ratings given in the inspection reports or as defined in the Technical Procedure for Principal Inspection to ensure continued structural integrity and public safety

Standards : Standards in relation to maintenance operations are those set in one or more of the following as appropriate to the operation concerned;

- to comply with one or more Italian Standard specifications or other Government manual, Guide or Code of Practice
- to comply with original structural drawings or current drawings as revised or accepted by SdM
- to conform with accepted safety standards

- to conform with components' manufacturers' Maintenance Manuals, specifications or recommendations
- as specified by SdM

All parts of Messina Strait Bridge shall be maintained, including replacement or repair as necessary, to ensure that these aims are achieved.

All maintenance work and servicing defined in the Manual shall be carried out to the satisfaction of SdM. It excludes work on equipment owned by statutory undertakers.

The Bridge is made up of a large number of Bridge Elements with different elements having varying maintenance requirements. The object of this manual is to consider each element and to develop the optimum maintenance requirement for each element. Maintenance requirements can be divided across a number of general headings:

6.2 Preventative Maintenance

Preventative Maintenance is considered to be the maintenance activities carried out at appropriate times to ensure that there is no avoidable loss of use of any part of the facility. Preventative Maintenance will include 'Defined Maintenance', i.e. where manufacturer's requirements or recommendations are defined and implemented and 'Planned Corrective Maintenance' which will depend upon adequate inspection and monitoring to identify in good time when repairs or maintenance work should be undertaken. Planned Corrective Maintenance can be planned to ensure that any interference with the operation of the asset is minimised.

Aspects of Preventative Maintenance are described in the following subsections.

6.2.1 Manufacturer Defined Maintenance (Defined Maintenance)

This applies to elements where the manufacturer has recommended or stipulated the actions to be taken and the intervals between such actions. The period may be defined by calendar periods or by working hours. Examples would include;

- Checking of oil levels
- Changing of filters

- Changing of drive belts.

Manufacturer defined maintenance is corresponding to Fixed Time Maintenance (FTM) as described in ref. [2].

6.2.2 Anticipated Service Life (Defined or Planned Corrective Maintenance)

This would be expected to apply to all mechanical and electrical components and systems and also to other bridge elements with a finite service life that is below the design life of the bridge. Inspection of such elements would be expected to increase as the age of the element increased and in some cases, replacement may be delayed by planned corrective maintenance. Examples would include:

- Paint systems
- Protective sheaths
- Bearings
- Expansion joints
- Buffer systems
- Gantries.

6.2.3 Managed Intervention (Planned Corrective Maintenance)

Managed intervention should be applied to the majority of the steel structure where it is not possible to define appropriate maintenance intervention periods. Similar elements in different locations across the bridge should be expected to behave in different ways. Some elements that are more prone to developing defects will be identified during the design stages, e.g. fatigue sensitive details. Other elements may be more prone due to issues such as variability in the quality of materials and workmanship and other construction related events. In order to identify, in good time, areas where repair or improvements are needed, it is essential that a rigorous inspection and testing regime is established and implemented. In this way bridge elements, or zones, that are more prone to developing defects can be identified and analysed so that appropriate repair techniques can be developed and implemented and the inspection regimes can be adjusted to ensure that known vulnerable areas are inspected at greater frequencies. Early identification of defects will, in most instances, allow the defect to be monitored until repaired under a planned and managed corrective maintenance regime.

6.3 Unplanned Corrective Maintenance (Reactive Maintenance)

Unplanned Corrective Maintenance, which may also be referred to as Reactive Maintenance, will be required where an unscheduled event such as a road traffic incident occurs and requires prompt and effective repair procedures to be available to restore the structure to the required condition. The effectiveness of Unplanned Maintenance will depend upon the readiness of the maintenance organization to respond to such events. Many aspects of unplanned corrective maintenance can be considered and assessed before an associated event occurs. In this way, procedures, equipment and training can all be prepared to ensure that the disruption caused is minimised and controlled.

By developing a strong maintenance strategy it is expected that the amount of Unplanned Corrective Maintenance work can be reduced to the absolute minimum and in instances where it does occur there are strategies in place to react promptly and effectively. Failure to detect defects at an early stage may result in restrictions in the use of the bridge and a need for emergency and/or temporary repairs being hastily carried out. Similarly, plans need to be in place to be able to respond to a range of likely incidents such as damage to traffic barriers when impacted by errant vehicles or road surfacing damage caused by fuel spillage. An adequate supply of spare parts and equipment is necessary to ensure a prompt response is possible to each of the envisaged scenarios.

6.4 Corrective Maintenance Activities

Corrective maintenance will include work such as remedial painting, weld repairs, patch repairs to sheathing, crash barrier repair/replacement etc. During the operational phase of the bridge there will inevitably be a plethora of such repair and remedial work activities that will be necessary to maintain the bridge in its optimum condition. Consideration should be given to preparation of suitable method statements at the appropriate time to ensure that such remedial work can proceed without delay. Technical Procedures will be developed to address many such items. The Technical Manager should instigate the development of such further procedures and also ensure that the necessary equipment and materials are available in good time.

6.5 Condition Based Maintenance

Condition Based Maintenance is for elements where continuous monitoring can be applied and repair or replacement can be carried out in time.

By Condition Based Maintenance, minimum inspections are required but a frequent check and evaluation of monitoring data is needed.

6.6 Spare Parts

For the development of this maintenance manual a schedule of bridge elements is being produced in the form of Component Sheets; these are discussed in Section 4.4. Each Component Sheet will identify whether spare parts should be provided for the particular elements. The Component sheets will also identify whether a repair procedure should be developed; in such cases a spare part may not be required but the materials and equipment necessary to effect a repair are needed, e.g. a patch repair ability for damage to the main cable neoprene wrapping. Examples of the Component Sheets are included within **Appendix 4.4.A**. The Component sheets should be reviewed throughout the construction phase and expanded to identify, in more detail, the specific requirements not only for spare parts but for materials and specialist repair equipment necessary for effective maintenance.

The need for spare parts has to do with maintenance strategy as well. Maintenance strategies are considered for dehumidification systems, structural health monitoring system (SHMS) and expansion joints for both roadway and railway girders in ref. [2].

The performed Failure Mode, Effect and Criticality Analyses (FMECA) and Inspection and Maintenance Activity Analyses (IMAA) have also revealed a need for spare parts for the various structural elements and technological systems, refer Appendix C in [2].

In case the considerations above, via the work contracts for construction of the bridge, result in a supply of certain parts and equipment an inventory must be prepared. Supplied spare parts and equipment can be used by the Inspection & Maintenance Organization (IMO) throughout the period of the Contract. The inventory shall be updated by the IMO and submitted regularly to SdM. The IMO will be expected to maintain an adequate amount of spare parts.

Spare parts are to be stored in a secure area where they can be protected from deterioration, loss or damage. An inventory system will be developed to manage and control storage, identification and timely replenishment of spare parts.

6.7 List of Relevant Manufacturer's Maintenance Manuals

When the various Maintenance Manuals from the manufacturers are available a list of manuals will be prepared and inserted as an appendix to the Inspection and Maintenance Manual.

6.8 Technical Procedures and Instructions for Maintenance

With reference to section 5.11 Technical Procedures and Instructions will also be developed for some maintenance works, which are foreseen.

As in section 5.11 the following sub-sections deal with topics for various structures and installations which the still unprepared technical procedures and instructions for maintenance must include.

The list of mentioned topics is not complete and some structural elements and installations with planned preventative maintenance are not mentioned.

The same examples of structures and installations as dealt with in section 5.11 are included here.

6.8.1 Steel Structures, Girders and Towers

Corrosion Protection

A Technical Procedure and Instruction will be developed for maintenance of steel surfaces in connection with the construction. During the construction the contractor will need to do some paint repairs and based on the actual process and products used, an instruction will be developed by the contractor.

Based on experience a suitable instruction will be prepared and will develop as a Technical Instruction for the approaching maintenance of the bridge.

Weld Defect Repairs

Repairs to welded connections are only to be carried out by approved welders working to approved welding procedures.

Bolted connections

Broken or missing bolts or tie rods shall be reported and replaced immediately on a like for like basis.

Loose bolts are to be re-tightened or replaced on the basis of the severity rating (refer Technical Procedure for Principal Inspection, Appendix 5.10.C) or relevant maintenance manual. Re-tightening will be permitted for severity rating 2 but replacement is necessary for severity rating 3 when more than 10% of the bolts are affected.

When bolts are replaced (or re-tightened if permitted) adjacent bolts shall be checked for tightness.

6.8.2 Bridge Cable Clamps and Posts

A Procedure and Instruction as mentioned in the previous section will be developed to cover the cable clamps and handstrand posts.

In the same way it will be developed during construction in connection with repair of inevitable damage to the painted areas.

Other procedures/instructions for potential repairs are mentioned in the Technical Procedure for Inspection and Maintenance of Bridge Suspension System, see **Appendix 5.10.A.**

6.8.3 Carriageway Surfacing

A technical procedure and instruction should be developed during the construction based on the inevitable repair works during the surfacing work, where the contractor must develop a repair instruction, or series of instructions depending of the size of areas to be repaired.

Typically the thin resin based surfacing during the first 10 to 15 years is not expected to require maintenance except mechanical damage from the traffic, e.g. cuts and grooves from traffic or wear on the chippings. The repair is easily done by removing the thin surfacing at the damaged area by hand grinder, shot blasting or by small milling machine. Removed materials in the damaged areas are substituted with new materials with same build-up. If Methyl methacrylate (MMA) is used smaller damages (size of up to 10-50 m^2) can be fully replaced within one day. Patch repair on carriageway should only be done when traffic intensity is low and whole stretches can be closed for traffic.

Partial replacement of the surfacing is possible if fatigue cracking appears in local areas over the supports.

In case low friction appears it is possible to apply new friction course on top of the existing surfacing.

Mechanical damage to the surfacing will occur but such damage may also affect the structural steelwork. Repairs to the steelwork should therefore be anticipated as part of surfacing mechanical damage repairs.

The surfacing material is resistant to chemical damage (e.g. oil, diesel, petrol), provided it is cleaned promptly. However, fire damage will require a full repair of the associated area.

Weld repairs to the underside of the deck plate will damage the surfacing above. Such repairs should instigate an inspection of the associated surfacing above. It may be anticipated that a repair to the surfacing should be undertaken within the following twelve months.

6.8.4 Bearings

No maintenance works are planned for the bearings other than ensuring that they are kept in a clean condition. Though patch repair of the painting may be necessary.

6.8.5 Expansion Joints

6.8.5.1 Roadway Expansion Joints

Roadway expansion joints will require periodical replacement of seals and wearing parts; experience has shown that minor repair works may be needed e.g. reinstalling of bearings and sliding springs after they have come out of correct position. Experience has also shown the need for replacement of the control springs for certain types of joint.

Cleaning between the tightening strips will be necessary and there may be mechanical damage on the tightening strips which require replacement.

6.8.5.2 Railway Expansion Joints

Cleaning of the expansion joints will be necessary and lubrication of the equalizer system must be anticipated.

6.8.6 Hydraulic Buffers

The maintenance part of the Technical Instruction will be covered by the Technical Instruction "Inspection and Maintenance of the hydraulic buffers", which mainly will be based on the suppliers recommendations, see besides section 5.11.6.

Replacement of a single buffer D1 is possible without any restrictions except strong wind. Limits for allowable wind speed must be considered in details.

Replacement of a single buffer D2 is also possible without any restrictions except during very high and low temperatures. Allowable temperature range must be considered in details.

In case of earthquake all buffers must be adjusted.

6.8.7 Access Facilities - Moveable

Nothing to add in relation to already mentioned in section 5.11.7.

6.8.8 Dehumidification System

The maintenance part of the Technical Instruction will be covered by the Technical Instruction "Inspection and maintenance of the Dehumidification System", which mainly will be based on the suppliers recommendations, see also section 5.11.8.

7 Operational Constraints

As mentioned earlier in Section 2.4, it is essential for all maintenance personnel to be aware of the operational constraints that will affect their activities. Reference must therefore be made to the Operations and Emergency Manual, the report "Risk evaluation principles" (ref. [4]) and other documents covering operational, safety and control measures for all users of the bridge. Inspection and Maintenance personnel will be required to work in a variety of locations throughout the structure. Several activities will need to be carried out in locations where there will be obvious and less apparent hazards. Risk assessments should be carried out as appropriate to allow Operational Procedures to be developed to address all envisaged hazards and activities.

The following is a non-exhaustive list of headings that will need to be considered during the development of the operational procedures for inclusion in the O&E Manual:

- Working in confined spaces.
- Working at height.
- Working close to, or above, live traffic.
- Working within the railway envelope.
- Effect of weather on safe working.
- Undertaking activities that may be a distraction to drivers.

Each of the above hazards may result in control measures being introduced that affect the way in which the inspection and maintenance personnel are allowed to work. Management may instil in their staff that such measures are in place for their safety or for the safety of others. Staff should be encouraged to contribute to reviews of the procedures to ensure not only that they understand their background and basis but also to allow them to put forward alternative views for consideration.

Table 5-3 in Operation and Emergency Manual [1] gives the overall preliminary proposal on criteria on ambient conditions for carrying out inspections and maintenance works on the bridge.

When the traffic pattern and intensity is known the conditions for performing of various maintenance and inspection works depending of necessary traffic restrictions should be considered and defined.

Other operational constraints that should be allowed for is the development of a procedure for the management of requests from hauliers for the passage of abnormal loads. Abnormal indivisible loads (AILs) may be abnormal due to their weight, their axle configuration, their width, their height, their speed of travel or combinations of each of these. A specific procedure for passage of Special Road Vehicles is included in the O&E Manual [1]. The Inspection & Maintenance Organization may be involved if separate assessments, e.g. structural and geometrical, have to be done if the abnormal vehicle is out with the parameters permitted by the procedure.

8 Safety and Security

Safety procedures and instructions will be developed later in connection with preparation of the Operation & Emergency Manual and the Inspection & Maintenance Manual will refer to this.

Security procedures and instructions will also be developed in connection with preparation of the Operation and Emergency Manual. This Inspection and Maintenance Manual will refer to such procedures and instructions as appropriate.

When preparing the procedures and instructions it may be considered to whom on site, from toll takers and office staff to maintenance and inspection workers, the procedures and instructions apply to.

9 Quality

9.1 General Policy Statement of Quality Standards and Plans

The general policy will be to ensure that anyone undertaking works shall be aware of and adhere to the appropriate National and International Standards and Codes including taking account of ISO 9002 and environmental legislation and standards.

9.2 Comprehensive Staffing and Supervision Structure

9.2.1 Staff

At Figure 4-3 and Table 4-3 in the Operation & Emergency Manual [1] a proposed organization for the Inspection and Maintenance Organization is shown.

The general activities of the Inspection and Maintenance Organization is headed by a Technical Manager, who is supported by an Assistant Technical Manager.

Three Inspection teams are recommended, a team for each of the disciplines:

- Structures
- E & M (electrical and mechanical)
- Carriageways

Each Inspection team is managed by a Team Leader.

Depending on whether Stretto di Messina want to have their own people conducting the various inspections or want an external Consultant (or Contractor) to do the work, the size of the various teams will need to be decided. It is expected that the teams should be able to conduct the majority of routine inspections using in-house staff in cooperation with an appointed service contractor within each discipline who can be called upon as and when required.

It is expected that a similar arrangement will be in place for many of the routine maintenance activities. A group of in house staff will work through most routine maintenance activities but will be able to call upon external personnel to supplement the workforce as and when required..

The anticipated staff structure would therefore consist of the Team Leader in each discipline being supported by a small number of in-house staff that can undertake the majority of the routine inspection and maintenance tasks across a range of disciplines. Each team can be supplemented by the use of external consultants or contractors who can provide appropriate staff when requested to support the inspection or maintenance teams and undertake specific inspection or maintenance tasks.

Maintaining the various Operation and Maintenance Technical IT Systems should be headed by an IT System Manager. It is foreseen that the amount of work will vary significantly and as such works peaks are recommended to be covered by external consultants.

To manage the equipment and materials stored in the yard, a Yard Manger should be appointed. Alternatively, the yard management could also be a part of the service contractors' contract

Principal and a range of Special Inspections are likely be performed by external consultants, preferably by a consultant, who will be awarded a contract for a reasonable period, e.g. 4 years for all structural parts (and a corresponding consultant for E & M) with the option for extension of 1, 2 or 3 years, which will mean that the appointed consultant will have an opportunity to be familiar with the discipline area on the bridge.

For a bridge of the present size a contractor for the road and structures may be expected to have 10 - 15 persons engaged. There should always, 24 hours every day, be a road patrol (2 persons) available. The road patrol can easily cover the adjacent highway sections and not only the highway section on Messina Strait Bridge.

A service contractor for E&M may be expected to have 8 - 12 persons engaged.

Depending of to which level SdM wants to outsource the work an appropriate instruction fpr Purchasing of Technical Services to be developed.

9.2.2 Equipment

Besides the access facilities mentioned in section 11 other equipment must also be available. Examples of such equipment are outlined below.

9.2.2.1 Traffic Management equipment

To carry out maintenance work close to traffic it is necessary to have and use traffic management. Once traffic management is in place, it is possible to carry out the routine and non-routine tasks close to traffic in a safe manner.

9.2.2.2 Mobile equipment

A vehicle containing standard and special tools for purpose of corrective and preventative maintenance shall be available.

Furthermore the Inspection & Maintenance Organization shall have the following available for use on the carriageway:

- 1 Vehicle (type pickup) for the road patrol
- 1 Mobile vacuum cleaner and pressure washer (truck)
- 1 Truck with a small crane
- 1 Bridge inspection lift over and under road level (may be on rental basis)
- 2 trucks with TMA (truck mounted attenuator)
- 2 Road sign trailers
- 1 Ordinary trailer

Vehicles must be equipped with approved markings and lights.

At present stage it is assumed that no equipment for removing snow and de-icing during winter is necessary.

9.2.2.3 Special equipment

To carry out maintenance activities the following communication equipment shall be at disposal for the inspection and maintenance staff:

- Tetra Radios that are to be picked up at the Operational Control Centre (OCC). The ability for communication between the OCC and all areas on and in the bridge should be confirmed.
- It is assumed that everybody has a mobile phone, but the Tetra Radio system is the primary communication tool. The Operational Control Centre will keep a record of all mobile phone numbers.

The following special equipment shall also be available for the inspection and maintenance staff:

- A range of lamps and spotlights
- Ladders of different size
- A pair of block and tackles
- Transportable emergency generators
- Instrument for measuring air quality.
- Equipment and instruments for Principal and Special Inspection, Maintenance, etc. as described in the various Technical Procedures and Instructions.

9.2.2.4 Personal safety equipment

- Reflective safety vests, jackets and overalls.
- A hand held battery lamp
- Parachute type harness including safety lines
- Gloves
- Safety helmet

- Safety boots/shoes
- Ear protection
- Safety goggles
- Life jacket

9.3 Comprehensive Training Proposals for All Staff

9.3.1 General

As described in section 5, inspections are divided in the following three types:

- Routine Inspections
- Principal inspections
- Special inspections

The three types go progressively into more detail and each type has specific requirements for personnel. Further details are included in the following sections.

9.3.2 Qualifications of Inspection personnel

Routine Inspections

The inspector undertaking Routine Inspections should at least have the following qualifications and experience:

- Skilled craftsman, a former foreman for bridge construction or the like.
- Familiar with the Messina Strait Bridge.
- Able to recognize structural defects.
- Have a good understanding of construction methods, materials and associated hazards..

- Be able to report findings.
- Be in a fit and healthy condition.
- Be fully aware of the Health and Safety Procedures associated with the various inspections.

The inspector should preferably hold this position for many years, which will allow him to be become very familiar with the bridge and be better able to notice changes and development of damages that occur slowly.

Principal Inspections

The inspector undertaking Principal Inspections should at least have the following qualifications and experience:

- Educated engineer.
- Familiar with Messina Strait Bridge.
- Experience from bridge design - a good understanding of bridge structural characteristics and able to pinpoint critical areas.
- Experience from inspection - planning, execution and reporting of inspections. Have a good understanding of types of defect, their development and criticality.
- Experience from maintenance - knowledge of current best practice for preventative and corrective maintenance.
- Knowledge of construction methods and material technology in order to pinpoint critical zones.
- Experience as project manager.
- Be aware of and supportive of all necessary safety instruction for the actual inspection work concerned
- Be in a fit and healthy condition.

Depending on the type and scope of inspection the inspector should not, due to safety reasons, work alone, but together with another inspector or be the manager for a group of inspectors. The principal inspector should evaluate the qualifications of the assistant inspectors and ensure that they are informed and trained as described in section 9.3.3.

Special Inspections

Special Inspections will generally fall within two types. The first type being where most Inspectors would be well capable of completing the task, e.g. Special Inspections required following a minor traffic incident. Other Special Inspections would require a greater amount of knowledge and experience. Depending on the type of inspection and the inspector's particular qualifications such special inspections may be carried out in one of the following two ways:

- The inspector has the necessary competence to perform the special inspection himself and does so.
- The inspector does not have the necessary competence or technical qualifications and requires assistance from specialists, such as NDT technicians. In such cases the inspector would undertake the role of inspection/project manager, with overall responsibility for planning, coordination and reporting.

9.3.3 Information and training of inspection personnel

In addition to the qualifications listed above in section 9.3.2 inspection personnel should receive information and training. Ideally only personnel that are familiar with the bridge should perform the inspections. However, this is not practical for the following reasons:

- Renewal of personnel.
- Some inspections may require a team of inspectors, which will require supplemental personnel.
- Specialists (such as NDT technicians) may not be familiar with the bridge.

The Team Leader should be responsible for providing appropriate information and for ensuring that any necessary training is arranged for the inspection and maintenance personnel; such training will include technical issues as well as safety instructions. The following items should be considered:

- General information about the bridge including design characteristics and materials used.
- Specific information on the elements to be inspected including information from earlier inspections.
- Instructions with regards to the inspection at hand, including object identification, terminology, inspection methods, equipment, reporting and evaluation criteria and areas for special attention.
- Information on access routes and procedures for safety and security. Identification of confined spaces or restricted access areas.
- Restrictions on use of specialist facilities, such as gantries, inspection carriages, lifts, etc. (e.g. permit to use items)
- Safety precautions, such as safety harnesses, protective glasses, etc.

Basic information for inspections includes:

- This Inspection and Maintenance Manual.
- Bridge drawings and other documentation.
- Reports from earlier inspections.
- O&E Manual [1]
- All relevant Health and Safety Procedures.
- Other relevant manuals

9.4 Comprehensive Method Statements

Clients from other major bridges have good experiences with method statements prepared ahead of use for general repair works in order to get the work done in the same way independent of the performing contractor.

Typically repair works with method statements prepared in advance could be:

- Repair of concrete
- Surface treatment of steel structures, e.g. painted surfaces and galvanized surfaces For paint repairs there may be various method statements depending on the size and depth (to which of the layers the damage of the paint has reached).
- Repair of surfacing.
  Again there may be more statements depending on the size and depth of damaged area.

Method statements, prepared ahead or for the occasion, for all maintenance procedures shall be submitted by the Inspection & Maintenance Organization to SdM for approval. They should be in a standard format, as approved by SdM, and incorporate, when necessary, standard headings.

It is a requirement that all materials used in maintenance of the structures shall be to a quality defined in the Contract Specification (for construction of the bridge) and the Final Inspection & Maintenance Manual or otherwise subject to review by SdM.

9.5 Comprehensive Record Keeping and Information Retrieval Systems

This is discussed in Section 10.

10 Collection, Recording and Analysis of the In-Service data

10.1 Introduction

The objective of this Section 10 is to outline a strategy for the collection and recording of the in-service data. Once such information is stored on a database (the Maintenance Log) it can be analysed by the inspecting and maintaining authority so as to enable effective monitoring of the bridge management procedures.

The effectiveness of the Maintenance Log will be determined by its ability to provide the required detail. When developing the database it is essential to determine what output will be required from it to ensure that the necessary input is provided to it.

The data are recorded in the Maintenance Log. The manner by which the various forms of data are captured and transferred to the database will be determined at a later date to suit the technology available at the appropriate time. This Section will describe the details that are to be recorded.

The purpose of the Maintenance Log is fulfilled by:

- keeping a chronological record of inspections and summaries of the inspection reports.
- keeping a chronological record of the condition and any operational disorder.
- keeping a chronological record of maintenance works.
- supporting other bridge management activities by making the above data available when needed for any particular emergency, operation and maintenance activities.

All data in the log are related to the hierarchical structure of the Messina Strait Bridge as described in Section 4.

The data relating to the inspection and maintenance activities may be analysed and used to generate different types of reports:

- Some data need only be stored for short periods and may be summarised in annual reports setting out the basis for, e.g.:
  - Decision on replacement of M&E components.
  - To check need for undertaking special inspections or maintenance works.
- Other data are stored for the whole lifetime of the Messina Strait Bridge and may be used, for example, to evaluate:
  - Performance of works carried out by external parties (suppliers / contractors / consultants).
  - The projected Service Life of major structural elements.
  - The rate of deterioration of structural parts, e.g. wear of bearings.

All data should be stored in the database of the Bridge Management System and files should be kept to a minimum after the registration of the data in the database.

Use of electronic signatures to be used in reports prepared by inspection and maintenance staff will be developed.

10.2 Components and Facilities to be Monitored

The components to be monitored are the structural elements and technological systems in the Element Hierarchy, refer section 4.

Elements that provide moveable access to various parts of the bridge superstructure will be monitored as described below. The principal facilities that provide such access are:

- Tower and Crossbeam Gantries
- Main Cable Gantries and Hanger Inspection Baskets
- Underdeck Gantries
- Elevators in tower legs (Lifts)

These facilities shall be monitored to enable the costs and time necessary for inspecting and maintaining the facilities to be assessed and compared with the time these facilities are in use for their various purposes. This monitoring will allow an accurate and viable comparison to be made in the future between like-for-like replacement and consideration of alternative forms of access.

A proposal for a performance log for moveable access facilities is shown in **Appendix 10.2.A.**

10.3 Log of all Costs and Associated Events

For financial control, monitoring and budgetary purposes, cost details relating to inspection and maintenance activities should be entered into the database.

Wherever possible (and reasonably straightforward), costs should be allocated to the structural elements and technological systems in the Hierarchy. Where viable, the costs should be allocated to elements at Level 5, otherwise at Level 6. Experiences from other major bridges have shown that it is important to make a careful consideration of to which level costs are recorded. In case of choosing a too detailed level, costs are then not registered because it creates too much work. E.g. in case of painting (or repair of the paint) of the box girders it will be reasonable and feasible to register the cost for the railway girder and the roadway girders in each direction (Sicily and

Calabria) separately and whether it is in the main span or side spans, but starting to allocate the costs for each segment is too difficult. On the other hand the level must not be chosen to high, in this case e.g. level 4 "Deck", because then the recording does not give much value for later budgeting.

Inspection and maintenance activities will incur both direct and indirect costs. Examples of direct costs would include those costs that can be clearly allocated to the task, e.g. in-house or sub-contractor operatives allocated to a task using parts or materials specifically purchased for that task. Sub-contract costs for labour and materials should be set out in the required detail on the suppliers invoice; hourly equivalent costs of in-house labour will need to be established once the selected financial management system is in place.

Examples of indirect costs would include those costs which are too general to allocate to a task, e.g. general office administration and welfare facilities, office staff, site transport; these costs should be applied as a percentage addition to the direct costs.

The exact details for inclusion on the database and the manner in which costs are allocated will depend upon the selected financial management system adopted. However, the following data, referenced to the hierarchy elements, should be recorded to allow the necessary cost detail to be derived:

- Work Order Reference.
- Dates work undertaken.
- Record of sub contract operatives and time spent by each.
- Record of in house staff and time spent by each.
- Spare Parts taken from stores with requisition reference.
- Invoice details.
- Record of use of any moveable bridge access equipment.

10.4 Log of all Inspections, Repairs and Replacement

The following activities should be entered into the maintenance log:

- Inspection activities
- Maintenance works.

All data should be entered chronologically into the maintenance log related to the element hierarchy. The maintenance log should be related to structural elements and technological systems at level 5/6 of the hierarchy elements.

The Team Leaders in charge of the inspection activities, or the contractors in charge of the maintenance activities, shall in general enter all data in the maintenance log (external persons shall be given limited access to enter data only). The data shall be entered as an integral part of reporting the activities. Data collection equipment will be specified through the Bridge Management System (BMS) report. Decisions on the optimum specification of such equipment will be made as late as possible.

10.4.1 Inspection Activities

The following data shall be recorded for each inspection activity:

- Work Order reference (including amendments).
- Element reference (from Element Hierarchy)
- Location reference (where only part of Element is inspected).
- Type of Inspection (routine, principal, special, works acceptance) and reference to Inspection Report No.
- Date of Inspection.
- Inspection Leader and support staff.
- Sub-contractor involvement (order reference, if applicable).
- Reference to previous associated inspection records.
- Defects Summary (reference to defect record)

- Details of any follow up activity required (defect severity 3/4, a part of the RBI framework or other reasons).
- Date for Review of follow up action taken (i.e. reminder date to check progress).
- Comments on action taken by the review date (renew Review Date if required).
- General comments relating to the inspection.
- No further action required (enter name and date).

10.4.2 Maintenance Works

The following data shall be recorded for each maintenance activity:

- Work Order reference (including amendments)
- Element reference (from Element Hierarchy)
- Location reference (where only part of Element is maintained).
- Reason for Maintenance (Functional, Routine Servicing, Repair, Parts Replacement, etc)
- Date of Maintenance (include due date if appropriate).
- Maintenance Leader and support staff.
- Sub-contractor involvement (order reference, if applicable – include designer details).
- Reference to any associated inspection records (Defect Record).
- Summary of work carried out (reference to works record – defects addressed).
- Details of any follow up activity required (e.g. replacement of spare parts used).
- Track of replaceable items (e.g. an emergency telephone is replaced and send for repair, then back to storage and later used on a new location on the bridge).
- Date for Review of follow up action taken (i.e. reminder date to check progress).
- Comments on action taken by the review date (renew Review Date if required).

- General comments relating to the activity.
- Work Order complete, i.e. name and date (actions complete and comments addressed).

For each of the above, it should be analysed if findings should result in updating of the RBI and RCM programmes.

10.5 Log of all Faults and Periods of Out-of Service of Bridge Element

A log to register all faults and periods of Out of Service will be established covering all structural elements and technological systems at level 5/6 of the hierarchy elements.

The expected use of the log will primarily be for the technological systems, while periods Out of Service for the structural elements is expected to be very limited.

The following data shall be recorded for each fault and period of out-of-service of bridge element:

- Type of fault
- Cause of fault
- Start of out-of-service period
- End of out of-service period
- Registered by

11 Programmes

11.1 Inspection Programme

The proposed inspection programme is shown in Appendix 11.1.A. The programme contains the following planned inspections:

Routine Superficial Inspections

Routine General Inspections

Principal Inspections (determination of frequency generally based on performed. Failure Mode, Effects and Criticality Analysis (FMECA) and Inspection and Maintenance Activity Analysis (IMAA) ref. [2], engineering judgement and experience, typically a 6 year cycle.

Special Inspections according to RBI plans, ref. [2].

The present programme cover Main Cables, Towers and Box Girders, but must be extended to cover all other structures. Furthermore is shown an estimate of necessary resources on the schemes appended to the programme.

In Appendix F in [2] an overall representation and ranking of elements and systems with respect to principal inspection interval is enclosed. All inspection intervals are based on Failure Mode, Effects and Criticality Analysis (FMECA) and Inspection and Maintenance Activity Analysis (IMAA).

11.2 Maintenance Programme for Structural Elements

The shown maintenance programme in Appendix 11.2.A is based on the performed Life Cycle Cost Study, ref. [3], where the various major maintenance activities are described including a forecast of time for the specific activities.

11.3 Maintenance Programme for Technological Systems and Equipment

A maintenance programme for the technological systems and equipment is still not developed in this manual. According to [3] there is a foreseen yearly maintenance of technological systems starting 5 years after completion of the bridge, but not stating any specific items.

It has to be noted that maintenance of the Technological Systems is expected to amount to only a minor part of the accumulated budget.

The following provides a brief description of the various elements of Technological Systems and equipment. The maintenance programmes for the equipment described in Subsections 11.3.1 and 11.3.3 below will be provided from the equipment providers; these programmes will be coordinated in due course. For the fixed access equipment, described in Subsection 11.3.2 below, inspection and maintenance will be included within the programmes for the structural inspections of the bridge elements to which the access is connected.

The programme for equipment in Section 11.3.1 and 11.3.3 must also include the specific statutory inspections for the actual equipment.

11.3.1 Moving access equipment.

The following equipment will not be fixed to the structure but will be able to be moved to provide access to the designated areas. The majority of this equipment will be bespoke and as such will require development of associated manuals for commissioning, testing, operation and maintenance. Where rails or other fixtures have been provided for such equipment to operate the manuals should include for such items.

Concerning inspection of the moveable access facilities, see Section 5.11.7.

11.3.1.1 Underdeck gantries.

These are to provide access to all the underside parts of the suspended deck structure. It is proposed that four of these will be provided, one on each side span and two on the main span. These gantries are a truss arrangement resting on rails at the bridge edges with electrical and hydraulic power provided by a diesel generator. Each gantry will include two scissor lifts (see 11.3.1.5 below).

A procedure should be made ensuring that when gantry work is carried out below the girder, a notification is sent in advance to the VTS and the Coast Guard. The VTS and the Coast Guard shall additionally be kept informed of the location of the gantry, so that they can inform the passing vessels of the position of the gantry.

11.3.1.2 Main Cable gantries.

These are to provide access to all parts of the main cable and hangers system. It is proposed that a total of eight of these will be provided, one on each section of main cable. This number may be reduced to a total of three or four units. The gantries are a frame unit resting on the outer handstrand cable. Movement is provided by a winch at the tower tops attached by wire ropes to the cable gantry, however alternatives to providing movement are under consideration. Each gantry contains a hoist unit which is used for close inspection of the hanger cables (see 11.3.1.6 below).

11.3.1.3 Tower Leg Access Platforms

These are to provide access to all the external surfaces of the tower legs. It is proposed that there will be one set for each tower leg, i.e. a total of four sets.

11.3.1.4 Tower Cross Beam External Access Platforms.

These are to provide access to the external surfaces of the cross beams on each tower. It is proposed that there will be one platform for each cross beam, a total of six units. It is expected that these will travel along rails fixed to the top level of each crossbeam using electrical motors with power provided from the bridge electrical system.

11.3.1.5 Travelling telescopic platforms (Scissor Lifts)

There are two sets of this form of equipment. One set may be provided to give improved access within each of the tower cross beams, i.e. a total of six platforms. The other set is provided on the underdeck gantries with two platforms on each gantry, i.e. a total of eight. These units are expected to be electrically powered.

11.3.1.6 Hanger Cable Basket hoist.

These are to provide access to the individual hanger cables. One hoist is provided as part of each main cable gantry. The hoisting mechanism is not yet determined.

11.3.1.7 Tower lifts - Internal

These are to provide access to all levels of each tower leg. It is envisaged that there will be two lifts in each tower leg making a total of eight lifts. They will be electrically powered from the bridge supply.

11.3.1.8 Truck with aerial platform

This is to provide access to the terminal structures at each end of the suspended deck structure where the underdeck gantries are unable to access. The truck will be positioned on the access road with the platform cantilevering from the truck.

11.3.1.9 Climbing Gantries at terminal structures

These are to provide access to the bridge piers to the terminal structures.

11.3.2 Fixed access equipment.

The following equipment will consist of fixed platforms ladders and stairs that are provided to assist with access throughout the structure. This equipment will include beams or rails that have been provided to assist with the movement of materials and equipment within the bridge deck. It is expected that the fixed equipment will be fabricated from either steelwork or aluminium; as such the inspection of this metalwork will be undertaken in conjunction with the routine inspections of the adjacent structural steelwork.

11.3.2.1 Towers and Cross beams

Within each of the tower legs is a set of access stairs and in more restricted areas there are ladders. In the top cross beam there is a further stairway giving access to the tower top where further sets of stairs give access to the tower saddles.

11.3.2.2 Bridge Deck

Walkways are provided along each of the box girders with a runway beam fitted through the longitudinal access ways of the carriageway girders to assist with the movement of plant and equipment. The main entry points into the carriageway deck boxes are located at every twelfth cross girder (corresponding to every 360 m) with a fixed, suspended platform accessible from the access road cantilever. Access into the railway girder is via access ladders within the crossbeam.

11.3.2.3 Railway Platform

A fixed platform is provided along the full length of each side of the rail lines. Inspection and maintenance of this platform will need to be coordinated with the Railway Authority.

11.3.2.4 Platforms at bearing locations

In the area of the towers, below carriageway level, access is provided via a fixed platform to the bearings, transverse bracing and hydraulic buffers. At the terminal structures there are access stairs or ladders and platforms for the inspection of the bridge deck expansion joints and bearings.

11.3.2.5 Main cable anchorages

Within each of the cable anchorages are a series of stairways and platforms giving access to the various levels of these chambers.

11.3.3 Technological Systems and other Equipment.

The following details relate to technological systems and equipment that is not part of the bridge access systems. The requirements for inspection and maintenance will need to be established for each item.

11.3.3.1 Dehumidification System

In addition to the painting of the internal steelwork surfaces, corrosion protection to internal faces of steel elements is also provided by a dehumidification system that keeps the relative humidity levels below the threshold for corrosion to be able to take place. The following elements are protected by the dehumidification system:

- Main Cable Anchorages.
- Main Cable wires.
- Tower legs and crossbeams (internal).
- Deck box girders and cross girder (internal).

Concerning inspection and maintenance of the dehumidification system, see section 5.11.8 and 6.8.8, respectively.

11.3.3.2 Bridge Electrical system.

The bridge will have an electrical supply system to provide lighting and power to all necessary areas. This system will be subject to the associated regulations that set out the minimum requirements for inspection, testing and maintenance.

Further detailing is described in Section 12.3 and 12.4.

11.3.3.3 Maintenance vehicles

A fleet of vehicles is expected to be provided for operation and maintenance activities. These should be maintained in accordance with the manufacturers' guidelines.

11.3.3.4 Maintenance equipment.

Several items of specialist equipment may be held on site to ensure prompt response to the need for investigations and repairs. The following are examples of such equipment:

- Magnetic Particle Inspections.
- Ultrasonic Inspections.
- Pressure washers.
- Compressors.
- Generators.
- Winches.
- Survey equipment.

11.3.3.5 Technological Systems

See Section 12 – Technological Systems

12 Technological Systems

12.1 Scope of Technological Systems

With reference to section 4.3 the Technological Systems listed in the Element Hierarchy are divided in 4 major groups of technological systems;

- Management and Control System (MACS), which is subdivided in two sub-groups
  - Supervision, Control and Data Acquisition (SCADA)
  - Management, Maintenance and Simulations System (MMS)
- Electrical Systems
- Illumination Systems
- Mechanical and Hydraulic Systems

12.2 Management and Control System (MACS)

The Management and Control System (MACS) consists of two main parts; Supervision, Control and Data Acquisition (SCADA) system for use in Operation Control Centre for emergency and operation purposes, and Management, Maintenance and Simulations systems (MMS) for use in the Inspection & Maintenance Organization.

12.2.1 Supervision, Control and Data Acquisition (SCADA)

The SCADA system is the shell for the technology systems:

- Control & Monitoring System for Electrical and Mechanical (EMC)
- Railway Monitoring System (RM)
- Structural Health Monitoring System (SHMS)
- Safety and Anti Sabotage System (SSS)
- Traffic Management System (TMS)
- Telecommunication System (COM)

For description of each individual system, see the Management and Control System (MACS) report [7].

12.2.1.1 IT-related Operation and Maintenance for SCADA

Operation:

The System Manager is responsible for ensuring of the required functionality and integrity of the entire systems - the SCADA (and MMS system (see section 12.2.2)) and their Sub-systems.

The operation activities shall be carried out according to the specifications as described in the individual system manuals and according to the general system management manual, which shall be prepared for the entire system.

General operation activities include:

- User administration (user access, rights, passwords etc)
- Data management (ensuring compatibility in databases etc.)
- Back up of data

Maintenance:

The Technical Manager is responsible for the maintenance of the SCADA (and MMS (see Section 12.2.2)). This includes maintenance of the individual Sub-system and maintenance of the data transfer and monitoring facilities (user interface facilities) in the entire system.

General maintenance activities include:

- upgrading of basic standard systems and updating of customised parts accordingly
- extension of facilities in Sub-systems
- major upgrade of system, for instance due to exchange of IT-platforms
- upgrading of user interfaces and data transmission protocols to ensure compatibility with general IT-facilities

The Technical Manager is in these activities assisted by the System Manager. He will moreover be assisted by various IT-consultants and Bridge Maintenance Consultants as needed.

12.2.1.2 Inspection and Maintenance tasks to be performed

Every year or when recommended (e.g. according to the maintenance manuals or RBI/RCM reports) by the various suppliers of the technology systems a visual and functional inspection should be carried out.

The content of the inspections to be performed is shown but not limited to the various tasks mentioned in the table below

Table 12.1 Inspection tasks for technology systems for SCADA

Inspection task	**EMC**	**RM**	**SHMS**	**SSS**	**TMS**	**COM**
Functional test	X	X	X	X	X	X
Cleaning of cameras		X	X	X	X	
Cleaning of variable road signs					X	
Inspection of cables	X	X	X	X	X	X
Calibration of sensors		X	X	X		
Calibration						X

Maintenance manuals for the technology systems within the SCADA should be provided by the various suppliers of the systems.

12.2.1.3 Structural Health Monitoring System

When detailing the inspection and maintenance programme for the Structural Health Monitoring System the performed Failure Mode, Effects and Criticality Analysis (FMECA) and Inspection and Maintenance Activity Analysis (IMAA) (enclosed in Appendix C in [2]) must be applied.

12.2.2 Management, Maintenance and Simulations system (MMS)

The bridge is equipped with a Management, Maintenance and Simulations system (MMS), which enables the Inspection and Maintenance Organization to carry out the operation and maintenance of the Bridge structures and installations in a safe and structured manner.

MMS is a collection of controlling software applications with analysis and management sub-systems and interface to the technology systems controlled by SCADA, refer above.

The software applications controlled by MMS is:

- WSMS (Work Site Management System)
- BMS (WMPS) (Bridge Management System)
- ICMS (Information and Coordination Management System)
- EDMS (Electronic Document Management System)
- CSP (Computing of Simulations and Predictions)

Work Site Management System (WSMS) will not be in use once the construction of the bridge is completed, because the aim for this sub-system is to monitor work, materials and equipment during the construction. Therefore WSMS is of no interest for this manual.

The BMS is a tool for the Bridge Inspection and Maintenance Organization. Use of BMS shall help to ensure a proper maintenance management resulting in

- Safety on the bridge
- Regularity to the largest extent (full functionality)
- Fulfilment of the principles in Reliability Based Inspection (RBI) and Reliability Centred Maintenance (RCM)
- Cost optimal inspection and maintenance in the entire life period

The Information and Coordination Management System (ICMS) has the objective to support the Operation Control Centre staff when predefined information related to an event shall be distributed.

The information distribution is separated in two:

- The event is an accident
- The event obstructs the traffic

The Electronic Document Management System (EDMS) will handle project data and all formal project communication for all relevant parties: the Owner, the General Contractor, subcontractors/suppliers, third parties, etc. In the early stages of the Project, the Project Documentation is primarily used for monitoring of the construction work, but in the later stages the emphasis will be on the operation and maintenance of the entire Construction.

The sub-system Computing of Simulations and Predictions (CSP) will comprise of the following applications:

- Event Manager
- Structural Health Evaluation System
- Structural Simulation analysis (FE Model)
- Climate and Weather Simulation
- Traffic Simulation

The simulation software will be allowed to pull data from the relevant sub-systems for simulation, calibration and control purposes. Simulation results will be possible to report in the EDMS module and the conclusions of simulation investigations to be passed on to the ICMS.

It should be noted that all exchange of documents goes through EDMS. This means that there will be no transfer of documents between sub-systems, exclusive of EDMS.

Concerning IT-related operation and maintenance of MMS and its sub-systems refer section 12.2.1.1.

For further description of the sub-systems, see the Management and Control System (MACS) report [7].

12.3 Electrical Systems

12.3.1 Lightning Conductor

Lightning bonding conductors between the steel tower and concrete reinforcement in the tower base must be inspected and tested for continuity once a year by the Inspection and Maintenance Organization.

12.3.2 Electricity Supply

For the electricity supply installations

- power cables
- cable ways
- distribution panels

the Inspection and Maintenance Organization should carry out the inspection and maintenance described in the following sub-sections.

12.3.2.1 Power cables

Performing a visual inspection of the cables for defects every sixth year.

12.3.2.2 Cable ways

Performing a visual inspection of the cable ways including the brackets for defects and corrosion every sixth year.

Furthermore the mounting of the cables must be inspected for defects.

12.3.2.3 Distribution Panels

Performing a visual and functional inspection of the distribution panels every year.

The panels must be inspected for defects, moisture and dust and at the same time the panels must be cleaned.

Preventative maintenance by using thermography to detect heat patterns or temperature changes is recommended in order to make it possible to detect defects prior to costly downtime or monitor developing defects/problems in due time that maintenance can be scheduled during a planned downtime or when budget is available.

12.4 Illumination Systems

12.4.1 Internal Illumination

12.4.1.1 Internal Light

The internal light should be inspected by the Inspection and Maintenance Organization every second year depending of the daily use of the light in relation to the lifetime of the lamps, which should be informed by the supplier.

The visual and functional inspection should comprise but not be limited to:

- Inspection for defects
- Inspection of the power connections
- Test of the light

12.4.1.2 Emergency Light

The emergency light should be inspected by the Inspection and Maintenance Organization every second year or according to recommendation of the supplier.

The visual and functional inspection should comprise but not be limited to:

- Inspection for defects
- Measurement and test of batteries

12.4.2 External Illumination

The external illumination comprise of structural and road lights.

The lighting should be inspected by the Inspection and Maintenance Organization every second year depending of the daily use of the light in relation of the lifetime of the lamps, which should be informed by the supplier or according to recommendations from the supplier.

The visual and functional inspection should comprise but not be limited to:

- Inspection for defects and moisture
- Inspection of the power connections
- Cleaning of the light for bird droppings
- Test of the light

Most likely it will be necessary to clean the light more often than every second year.

12.4.3 Aviation and Navigation Warning Lights

The aviation and navigation warning lights should be inspected by the Inspection and Maintenance Organization every year or according to the suppliers' recommendations.

The visual and functional inspection should comprise but not be limited to:

- Inspection for defects and moisture
- Inspection of the power connections
- Cleaning of the light for bird droppings
- Test of the light

Most likely it will be necessary to clean the light more often than every second year.

The aviation warning light consists of three lamps (one in use and two spares) and when there is only one undamaged lamp left there will be an indication in the SCADA.

12.5 Mechanical and Hydraulic Systems

12.5.1 Water Supply

The water supply system consists of two separate systems:

- The fire hydrant system
- The utility water system (the washing system)

Two similar pump installations are located at each tower. The pump installations include water tanks, fire pump installations and utility water pump installations.

The fire pumps supply water to the entire bridge in fire mains located at the railway girder. The pump will further supply water to the fire risers inside the towers.

The fire mains are connected to fire hydrants located at intervals throughout the bridge and inside the towers.

The utility water mains are connected to wash valves located at intervals throughout the bridge and inside the towers.

Each pipe connection on bridge for fire hydrants and wash valves will be frost protected by means of electrical trace heating and insulation. Water will flow in the mains in case of low temperature (freezing risk).

In order to secure that the system operates satisfactorily, several inspections and functions tests have to be carried out, which are described in **Appendix 12.5.A.** Additional testing and inspection may be required during periods of low temperatures to ensure that the installed frost protection measures are acting effectively, ref. [8].

Appendix 12.5.A describes various maintenance works, but these will be included in the technical instruction for inspection and maintenance of fire hydrant system and washing system.

12.5.2 Surface Drainage

To collect rain water on bridge decks a gravity drain water pipe system will be installed inside the bridge girders.

The rain water will flow to shore for cleaning before discharge to the Messina Strait.

Rain water gullies will be located at intervals along the emergency lane on the roadway girders.

Rain water gullies will be located along both sides of the railway girder.

The discharge arrangement at the Sicilian and Calabrian side will consist of sedimentation reservoirs and oil separators. No further cleaning is foreseen.

INSPECTION OF GRAVITY PIPES

To prevent clogging of pipes due to a build up of sedimentation the pipes shall be inspected frequently.

The gravity pipes are designed for self cleaning during normal operation but, based on experience, the possible ingress of foreign bodies, such as cigarette packages and other trash, must be allowed for. As such, a water supply will be available along the bridge to allow the pipes to be flushed using high pressure washing equipment as necessary.

MAINTENANCE OF THE DISCHARGE ARRANGEMENT

The Sedimentation reservoir and the Oil and Petrol interceptor must be emptied regularly.

Clean up works, which often is carried out by services contractors having special equipment and experience of mud- and oil pumping.

Due to the circumstances it is found most relevant to include these maintenance works in the Technical Instruction "Inspection and maintenance of bridge drainage system".

12.6 Evaluation during inspection

When the inspections are carried out the various equipment/installations should be evaluated.

The scale for condition marks shown below has been used for other major bridges, but it has to be mentioned that the conditions for the various marks are different from the scale used for principal inspection of structures.

Table 12.2 Condition Marks when inspecting Technological Systems

Condition Mark	Description	Action
0	Irreproachable (equipment as new)	No
1	Good	No
2	Reasonable	Evaluation at next inspection
3	Bad condition	Replacement/repair the equipment before next inspection
4	Worthless	Immediate replacement or repair
X	Unclassified	Need inspection by a specialist

12.7 Technical Procedures and Instructions for Technological Systems

During the construction phase, when the technological systems are installed and the suppliers detailed instructions and maintenance manuals are delivered a detailed review must be performed of the instructions and manuals and based on the review relevant technical procedures and instructions must be developed.

The relevant technical procedures and instructions for the installations/equipment mentioned above must include the following:

- Statutory inspections, which also will be shown on the maintenance programme mentioned in Section 11.3, including interval for these inspections.
- A schedule for service inspections including service frequencies. The service will include preventative maintenance scheduling replacement of components with a certain lifetime, substitution of consumable parts, etc.
- Preparation of a list with components with a certain expected lifetime.
- Estimation of a suitable stock of components with a certain expected lifetime.

13 References

[1] Preliminary Operation and Emergency Manual, doc. no. CG.10.00-P-MI-D-P-GE-M7-00-00-00-00-01-A

[2] Reliability Based Inspection (RBI) and Reliability Centred Maintenance (RCM), doc. no. CG.10.00-P-RG-D-P-GE-R6-00-00-00-00-01-A

[3] Life Cycle Cost Study (LCC), doc. no. CG.10.00-P-RG-D-P-GE-L4-00-00-00-00-01-A

[4] Risk evaluation principles, doc. no. CG.10.00-P-RG-D-P-CG-00-00-00-00-00-08-A.

[5] Bridge Management System, doc. no. CG 10.00-P-2S-D-P-IT-M4-C3-00-00-00-04-A

[6] Performance Specification - Expansion Joints, Railway, doc. no. CG.10.00-P-SP-D-P-SS-A0-AM-00-00-00-00-A

[7] Management, Control and Simulation Systems (MACS), doc. no. CG10.00-P-RG-D-P-CG-00-00-00-00-00-06-A

[8] Design Specifications - Mecahanical and Electrical, doc. no. CG10.00-P-2S-D-P-IT-M4-C3-00-00-00-00-06-B

Appendix 3.1.A - Notes from meetings with design leaders

MESSINA BRIDGE – INSPECTION AND MAINTENANCE

Notes of Meetings with Design Team Leaders. Series 1: 29th and 30th June + 7th and 28th July 2010

MJU + XJDC Series 2: 2nd , 7th and 9th September 2010

Meeting No. 1 – Towers.

	29th June 2010. 11:30 until 12:30 Chris Scollard + Lars Jensen	**7th September 2010** e-mail response on previous notes. Chris Scollard
A	Tower structure is basically simple; fabricated plates with welded and bolted connections.	
B	Internal surfaces will have no protection other than original shop primer. Hence appearance at handover will be variable with some initial corrosion on older parts. Grinding flush welds is not specified.	
C	Main areas for inspection are the connections between the crossbeams and the tower legs due to tension primarily. However, the degree of concern has to be evaluated when the prefabricated crossbeams are welded to the tower legs and a judgement made of how the tolerances were met.	
D	Major area of concern would be the tower base holding down bolts. Potential for longer term corrosion so designed to be possible to replace. SHM should monitor this as visual inspections would not identify the problem in good time. Watch for any de-tensioning of the bolts.	
E	Seismic action is greatest concern – should follow up with a check of C and D plus the tower leg section above and below the central crossbeam. SHM should set alarm thresholds. Inspections should look for any noticeable change in smoothness of the steel panels, i.e. to look for any signs of buckling or distortion.	It is probably prudent to check all exterior plates, A, B, C and D.
F	Temperature and Lightning should not be a concern for the towers.	

G	Wind should not cause a concern although TMDs may be incorporated in each leg in order to damp any Vortex oscillation at wind speeds around 50 - 55 ms^{-1} in transverse direction of the bridge.	Wind loads govern the design of the cross beams.
H	When lifts are installed access to the steelwork behind the lift may not be possible.	
I	Access gantry details not yet confirmed. Concerns with present proposals; these are being reviewed.	
J	Specifications from Stretto di Messina are used with no addendum except that it is agreed that the yield stress for all plate thickness up to 100mm is the same and corresponds to yield stress for the thinnest plate.	We are designing for SILS using a material partial factor of 1.0. The design basis permits significant damage to the towers under SILS, and although we are not comfortable with allowing that level of damage, we do believe there should be some difference between the performance requirements for the ULS and SILS. The most convenient and appropriate way to consider some slightly increased level of utilisation for the SILS is to allow the material to reach its nominal yield strength.

Meeting No. 2 – Cable system.

	29th June 2010. 14:30 until 15:30 Ian Firth	**7th September 2010. 16:00 – 17:00** Chris Walker
A	Many cable details not finalised, several have changed from recent drawings. Specification not concluded; some additional clauses anticipated.	Comments were given on the current draft TP and associated TI's.
B	Wind should not trigger additional inspections but SHM would be useful on central hangers with bearings to confirm that movement occurs.	
C	Temperature should not trigger additional inspections but need to confirm temperature stability of main cable wrapping material.	
D	Seismic event should justify inspection of anchor blocks and tower saddles for signs of movement or distress.	
E	Main cable access gantries – the number and the design of these needs to be reviewed.	It is now expected that four gantries will be required. They may now use all four handstrand ropes for support – hence all ropes will be the same diameter.
F	Cable clamp bolt lengths will be re-measured by ultrasonic in the maintenance period and re-tensioned if necessary. Subsequently consider measuring all bolts in 10% of clamps every 6 years. If tension is more than XX% (c10%) reduced from target level then re-tension the group and check adjacent clamps.	
G	The clamp sealant detail is not finalised.	An additional insert may now be included to act as a seal between the cable clamp sections.
H	The anchor bars in the anchorages may also require measurement and re-tensioning but detail not finalised.	
I	Tower top access to main cable is not finalised but consider inspection of visible wires every six years if access is available.	Details not finalised but it is expected that the length of main cable at the tower tops between the highest cable clamps will be able to be exposed to allow inspection.
J	Access within anchorage will allow inspection of many parts but will not allow all parts to be touched.	Endoscopes may be necessary to allow some areas to be viewed.
K	One hanger cable (not both cables for one hanger) can be replaced without any traffic restrictions, refer Design Manual.	There will now be no more than one hanger on any cable clamp. All double hanger clamps have been revised.
l	An addendum to the construction specifications will be prepared in order to cover the design changes.	

J	Long term concerns are expected to be: • Ensuring that the bearings on the central main span hangers are functioning. • Ensuring that the top and bottom pins on the remaining hangers are free to move. • Ensuring that the main cable dehumidification is protecting the main cable.	Although these bearings are to be specified as 'maintenance free', they will include a facility for them to be greased.
K	The following spare parts should be considered: • Cable clamp bolts. • Handstrand posts. • Seals at Cable clamps. • Centre span hanger bearings. • Patch repair kit for sheath damage on hangers. • Patch repair kit for main cable wrapping.	Handstrand posts may have possible fatigue issues. This will be considered and inspection requirements noted. This is expected to include inspection of bolts and inserts where the handstrand rope is clamped to the top of the post.

Meeting No. 3 – Articulation.

	30th June 2010. 09:00 until 10:00 Søren Lausten (SOLA)	**7th September 2010. 15:00 until 15:20** Søren Lausten (SOLA)
A	A performance specification is being developed for the majority of articulation and expansion items. This is to allow the contractor to have some selection ability rather than being tied to a particular supplier.	Much detail has developed for the railway and carriageway expansion joints for I&M but very little for other items, other than the requirement for the supplier to provide a maintenance manual. MJU requested a link to enable him to view the current documents.
B	Maintenance limits and spare part proposals could be included within the specification. SOLA will pass a draft version to MJU during development.	
C	Most parts are designed to cope with a seismic 200 year event. For seismic events of intensity greater than 200 years there are controlled failure points incorporated, e.g. road expansion joint 'fuse' element at the terminal structures. Tower buffers would need to be checked to assess whether they should be re-set.	
D	Most bearings are expected to be spherical although some could be pot bearings. Uplift is possible on some bearings but it is expected that this would only be the case for the larger seismic events. All bearings will be replaceable parts.	
E	The central 'spider' at the towers contains maintenance free bearings which may be difficult to replace.	
F	Most parts will be protected using the standard paint system – this is not yet determined.	
G	Details of SHM links to the articulation systems is not known but some should be included – particularly for the hydraulic buffers at the towers.	
H	Access arrangements to the mechanisms at the towers are not yet determined.	
I	The hydraulic buffers at the towers are unique to Messina and as such will require inspections which will need to be targeted to particular issues. Other aspects are based on known technology but the loadings are greater for Messina.	
J	Consideration should be given to discourage birds from nesting within the areas close to the towers.	
K		No comments were given on the notes of the previous meeting.

Meeting No. 4 – Concrete foundations and anchorages.

	30th June 2010. 11:00 until 12:00 Arne Bisgard + Ib Jacobsen	**9th September 2010. 13:00 until 13:20** Arne Bisgard
A	There is a concrete crossbeam at the base of the tower legs which acts as a tie. This beam is post tensioned and the internal elements are accessible. Need to check for cracks and signs of water ingress.	No comments were given on the notes of the previous meeting. The tower holding down bolts on the external faces of the tower bases should be enclosed within a dehumidified zone as corrosion of these bolts would be a concern.
B	When inspecting the crossbeam care should be taken. This will be a confined space with poor air quality; it may be unlit and there may be water present. General inspection at two years and principal at 6 years appears reasonable.	
C	Most settlement should occur during construction but may be a need to monitor in early years.	
D	The revetment that will be constructed along the shore line should be included within the inspection of the tower bases.	
E	Seismic events may cause some ground slip and other damage at tower bases.	
F	Anchorages are massive structures but with only small areas available for inspection. Movement of about 100mm is anticipated during construction phase but subsequently only real concern would be seismic.	
G	Inspections should look for cracks, signs of water ingress and any evidence of change over time.	
H	Horizontally upturned concrete surfaces on the anchor blocks will be covered by a membrane.	

Meeting No. 5 – Deck Box Girders.

	30th June 2010. 13:00 until 14:00 Henrik Polk	**2nd September 2010. 09:30 – 10:00** Henrik Polk
A	Many details remain to be finalised; current design has not analysed fatigue.	
B	All internal surfaces will be dehumidified and hence unpainted.	Internal surfaces may now receive paint system of 240 microns as well as dehumidification.
C	Areas under wheel and rail tracks will require more detailed inspections. The fastening system for the rails will probably be changed from the embedded type to some form of direct fastening to the deck plate.	The rail fastening system may now revert to the embedded type.
D	The rail details are subject to the approval of the Italian Rail Authority.	
E	The internal drainage detail may be moved to exterior.	Internal drainage is now expected to remain as internal although the overflow may go direct to external discharge.
F	In due course, the FE model should identify 'hot spots' where more focussed attention may be need during inspections.	
G	Seismic events have not been analysed but expect to check the hanger anchorages and the deck crossover areas. SHM should identify areas of excessive movement of deck boxes.	
H	Specification is not yet written but will need to be done in conjunction with the tower and other structural steelwork elements.	
I	Access to the top of the cross girders may be required for inspection of parts fitted at this level, e.g. lighting columns – these fixings will need to be well detailed.	Access to the top of the cross girders has yet to be addressed.
J		Access for high voltage cables has now been provided in the carriageway girders. Electrical cabinets need to be positioned either internal or external.
K		There are concerns over the loading that is expected from the underdeck gantries. The dead load may increase and is already at the extremes of the cantilevers.
l		

Meeting No. 6 – Structural Health Monitoring (SHM) System.

	7th July 2010. 10:30 until 11:30 Jacob Andersen	**9th September 2010. 10:00 until 11:15** Simon de Neumann
A	The system gives warnings and alarms only – No automatic response, Operator decides action to be taken.	Single alarms will need to be investigated within the SHM system. Multiple simultaneous alarms will also be analysed but are likely to trigger site inspections.
B	The system will identify the locations with the worst response to seismic and other loadings.	SHM needs to receive details from designers as to areas being most highly utilised.
C	System includes a load measurement facility – this can identify abnormal load movements across the bridge.	The SHM System includes a load measurement facility – The Weigh-in-motion equipment is part of SCADA – TMS which can identify abnormal load movements across the bridge.
D	The SHM system will require maintenance. A strategy should be developed for the future, including requirements for functional testing at say 2 year intervals.	SHM system maintenance is expected to be provided by the supplier for the initial 5 year period.
E	Spares should be provided to ensure the installed system can operate effectively for 10-15 years. After this time equipment data collection and software upgrades should be expected to be necessary to allow the system to keep pace with developments with technology.	
F	SHM will monitor humidity levels but will not monitor the equipment.	
G	The present proposed system does not include acoustic monitoring of the main cables.	
H	Corrosion monitoring within the concrete tie beams at the tower bases can be included.	SHM will need to discuss this with the concrete foundations design team to assess what could and should be included.
I	Monitoring of movement of the spherical bearings to the short hangers can be included but not wear.	SHM will need to discuss this with the suspension system design team to assess what could and should be included.
J	The movement joints will be monitored.	
K	Movement of hydraulic dampers will be measured but not hydraulic pressure.	Movement of hydraulic dampers will be measured and also hydraulic pressure.
L	At the base of the towers, load is monitored in selected anchor rods.	
M	Review of the SHM data is necessary to identify adverse trends, e.g. slippage of anchorages.	
N	A peer review meeting for the SHM is planned for 12th August in London.	This meeting produced a range of actions which are being undertaken.

Meeting No. 7 – Carriageway Surfacing System.

	28th July 2010. 10:30 until 11:30 Jorn Blumensen	**7th September 2010** e-mail response on previous notes. Jorn Blumensen
A	The proposed surfacing system is expected to be a three layer system laid onto the blasted steel deck plate prepared to Standard SA2.5.	
B	The three layer system would be: i. Thin Primer, 0.3mm, brush or spray applied at 0.3Kg/Sq.m. ii. Membrane Layer, 2mm, brush or spray applied, 1.2kg/sq.m. iii. Wearing Course, 5-7mm, 2.5 – 3 Kg/sq.m. combined with an aggregate to give a total surfacing thickness of about 12mm.	
C	Steel deck fabrication would need to limit deflections between diaphragms to 5mm and along a section to 7mm. Overall surfacing thickness should be in the range, 7mm Min to 14mm Max.	The overall surfacing thickness should be in the range, 9mm Min to 14mm Max.
D	Weld caps on the deck plate will need to be reduced to 0.5mm.	
E	There is much research and testing to be done on the surfacing materials to determine many parameters such as viscosity, pot life, setting times, aggregate properties, durability etc. This research would include development of repair types and procedures and identify the required equipment.	
F	Mechanical damage to the surfacing will occur but such damage may also affect the structural steelwork. Repairs to the steelwork should therefore be anticipated as part of surfacing mechanical damage repairs.	
G	The surfacing material is resilient to chemical damage (e.g. oil, diesel, petrol), provided it is cleaned promptly. However, Fire damage will require a full repair of the associated area. Fire Damage will be added to the list of defect types.	The surfacing material is resistant to chemical damage.....
H	Weld repairs to the underside of the deck plate will damage the surfacing above. Such repairs should instigate an inspection of the associated surfacing above. It may be anticipated that a repair to the surfacing should be undertaken within the following twelve months.	
I	Repairs would be full depth for Item H and possibly Item F repairs but most other repairs would be only partial depth, e.g. loss of surface friction; remove material locally and replace.	
J	The specification would be based upon Danish National Standards.	

Appendix 4.2.A - Bridge Element Hierarchy, level 2 - 5

Level 2	Level 3	Level 4	Level 5	ID	Element
1				P	Suspension Bridge
	1			ST	Substructure
		1		F3	Tower Foundation
			1	TS	Tower Sicily
			2	TC	Tower Calabria
		2		B4	Anchor Blocks
			1	BS	Anchor Block - Sicily
			2	BC	Anchor Block - Calabria
		3		F4	Terminal Structures Foundations
			1	VS	Terminal Structures Sicily
			2	VC	Terminal Structures Calabria
		4		S6	External Arrangements
			1	TS	Tower Sicily
			2	TC	Tower Calabria
			3	BS	Anchor Block - Sicily
			4	BC	Anchor Block - Calabria
			5	VS	Terminal Sructures Sicily
			6	VC	Terminal Structures Calabria
	2			SV	Superstructures
		1		T4	Towers
			1	TS	Tower Sicily
			2	TC	Tower Calabria
		2		S7	Suspension System
			1	CO	Cable Clamps
			2	SL	Saddles
			3	PE	Hangers
			4	CA	Main Cables
			5	?	Handstrand Ropes
		3		I3	Deck
			1	CF	Railway Girder
			2	?	Roadway Girder, direction Sicily
			3	?	Roadway Girder, direction Calabria
			4	TP	Main Cross Girders
		4		S8	Terminal Structures
			1	VS	Terminal Structures Sicily
			2	VC	Terminal Structures Calabria
	3			SS	Secondary System
		1		R4	Secondary Structures
			1	CR	Service Lane
			2	BF	Wind Screens
			3	BA	Roadway Barriers
			4	?	Light Masts
			5	?	Cross Overs
			6	?	Service Area
			7	PA	Tower Gantries and Elevators
			8	?	Main Cables Carriage and Hanger Basket
			9	?	Gantries for Suspended Deck
			10	DU	Dehumidification System
		2		A0	Articulations
			1	AP	Bearings
			2	GE	Expansion Joints
			3	AM	Buffer
		3		P2	Platform
			1	SR	Roadway
			2	FE	Railway
	4			IT	Technological Systems
		1		M3	Monitoring Systems
			1	C1	Control & Monitoring System for Electric and Mechanic
			2	C2	Railway Monitoring System
			3	SM	SHMS Monitoring System
		2		F5	Railway Systems
			1	IS	Signal System
			2	TT	Telecommunication (Railway)
			3	TE	Overhead Electrics
		3		M2	Mechanical and Hydraulical
			1	DI	Water Supply
			2	AS	Surface Drainage
		4		E2	Electrical Systems
			1	SA	Lightning Conductor
			2	DE	Electric Supply MT/ST
			3	SI	Illumination System
		5		A3	Safety and Anti-Sabotage System (SSS)
		6		M4	Operation and Maintenance Systems
			1	C3	Operational - Logistics MACS
			2	C4	DWPMS
			3	C5	WSMS
			4	C6	BMS (WMPS)
			5	C7	ICMS
			6	C8	EDMS
			7	C9	CSP
			8	GT	TMS Traffic Management
		7		S9	Special Plants
			1	SC	Communication System

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Appendix 4.2.B - Bridge Element Hierarchy, level 2 - 6

Level 2	Level 3	Level 4	Level 5	Level 6	ID	Element
1					P	Suspension Bridge
	1				ST	Substructure
		1			F3	Tower Foundation
			1		TS	Tower Sicily
				1	G1	Leg North-East
				2	G2	Leg South-West
				3	G3	Cross Beam
			2		TC	Tower Calabria
				1	G1	Leg North-East
				2	G2	Leg South-West
				3	G3	Cross Beam
		2			B4	Anchor Blocks
			1		BS	Anchor Block - Sicily
			2		BC	Anchor Block - Calabria
		3			F4	Terminal Structures Foundations
			1		VS	Terminal Structures Sicily
				1	FD	Foundation
				2	PL	Piers
			2		VC	Terminal Structures Calabria
				1	FD	Foundation
				2	PL	Piers
		4			S6	External Arrangements
			1		TS	Tower Sicily
			2		TC	Tower Calabria
			3		BS	Anchor Block - Sicily
			4		BC	Anchor Block - Calabria
			5		VS	Terminal Structures Sicily
			6		VC	Terminal Structures Calabria
	2				SV	Superstructures
		1			T4	Towers
			1		TS	Tower Sicily
				1	G1	Leg North-East
				2	G2	Leg South-West
				3	TO	Cross Beams
			2		TC	Tower Calabria
				1	G1	Leg North-East
				2	G2	Leg South-West
				3	TO	Cross Beams
		2			S7	Suspension System
			1		CO	Cable Clamps
				1	MS	Main Span
				2	?	Side Span Sicily
				3	?	Side Span Calabria
			2		SL	Saddles
				1	SA	Splay Saddles
				2	ST	Tower saddles
			3		PE	Hangers
				1	?	Main Span
				2	?	Side Span Sicily
				3	?	Side Span Calabria
			4	1	CA	Main Cables
			5	1	?	Handstrand Ropes
		3			I3	Deck
			1		CF	Railway Girder
				1	MS	Main Span
				2	?	Side Span Sicily
				3	?	Side Span Calabria
			2		?	Roadway Girder, direction Sicily
				1	MS	Main Span
				2	?	Side Span Sicily
				3	?	Side Span Calabria
			3		?	Roadway Girder, direction Calabria
				1	MS	Main Span
				2	?	Side Span Sicily
				3	?	Side Span Calabria
			4		TP	Main Cross Girders
				1	MS	Main Span
				2	LS	Side Span
		4			S8	Terminal Structures
			1		VS	Terminal Structures Sicily
				1	SC	Longitudinal Steel
				2	S1	Slab
				3	?	Bottom Plate
			2		VC	Terminal Structures Calabria
				1	SC	Longitudinal Steel
				2	S1	Slab
				3	?	Bottom Plate
	3				SS	Secondary System
		1			R4	Secondary Structures
			1		CR	Service Lane
				1	?	Service Lane, direction Sicily
				2	?	Service Lane, direction Calabria
			2		BF	Wind Screens

Level 2	Level 3	Level 4	Level 5	Level 6	ID	Element
				1	?	Wind Screens, direction Sicily
				2	?	Wind Screens, direction Calabria
			3		BA	Roadway Barriers
				1	?	Roadway Barriers, direction Sicily
				2	?	Roadway Barriers, direction Calabria
			4		?	Light masts
				1	?	Light masts, direction Sicily
				2	?	Light masts, direction Calabria
			5		?	Cross Overs
				1	?	Cross Overs, direction Sicily
				2	?	Cross Overs, direction Calabra
			6		?	Service Areas
				1	?	Service Areas, direction Sicily
				2	?	Service Areas, direction Calabria
			7		PA	Tower Gantries and Elevators
				1	?	Tower Gantries, Sicily Tower
				2	?	Tower Gantries, Calabria Tower
				3	?	Elevators, Sicily Tower
				4	?	Elevators, Calabria Tower
			8		?	Main Cables Carriages and Hanger Baskets
			9		?	Gantries for Suspended Deck
				1	?	Gantry for side span - Sicily
				2	?	Gantry for main span - Sicily
				3	?	Gantry for main span - Calabria
				4	?	Gantry for side span - Calabria
			10		DU	Dehumidification System
		2			**A0**	**Articulations**
			1		AP	Bearings
				1	?	Roadway Bearings, direction Sicily
				2	?	Roadway Bearings, direction Calabria
				3	FB	Railway Bearings
				4	?	Transverse support of suspended deck
			2		GE	Expansion Joints
				1	?	Roadway Joints, direction Sicily
				2	?	Roadway Joints, direction Calabria
				3	FJ	Railway Joints
			3		AM	Buffer
				1	?	Hydraulic Buffers - Tower
				2	?	Hydraulic Buffers - Terminal Structures
		3			**P2**	**Platform**
			1		SR	Roadway
				1	CS	Carriageway direction Sicily
				2	CC	Carriageway direction Calabria
			2		FE	Railway
				1	BP	Even track
				2	BD	Odd Track
	4				**IT**	**Technological Systems**
		1			**M3**	**Monitoring Systems**
			1		C1	Control & Monitoring System for Electric and Mechanic
			2		C2	Railway Monitoring System
			3		SM	SHMS Monitoring System
		2			**F5**	**Railway Systems**
			1		IS	Signal System
			2		TT	Telecommunication (Railway)
			3		TE	Overhead Electrics
		3			**M2**	**Mechanical and Hydraulical**
			1		DI	Water Supply
			2		AS	Surface Drainage
		4			**E2**	**Electrical Systems**
			1		SA	Lightning Conductor
			2		DE	Electric Supply MT/ST
			3		SI	Illumination System
				1	IN	Internal Illumination
				2	EX	External Illumination
				3	AN	Aviation and Navigation Warning Light
		5			**A3**	**Safety and Anti-Sabotage System (SSS)**
		6			**M4**	**Operation and Maintenance Systems**
			1		C3	Operational - Logistics MACS
			2		C4	DWPMS
			3		C5	WSMS
			4		C6	BMS (WMPS)
			5		C7	ICMS
			6		C8	EDMS
			7		C9	CSP
			8		GT	TMS Traffic Management
		7			**S9**	**Special Plants**
			1		SC	Communication System
				1	DS	Data Communication
				2	TC	Telecommunication

Appendix 4.2.C - Bridge Element Hierarchy, level 2 - 7

Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	ID	Element
1						P	Suspension Bridge
	1					ST	Substructure
		1				F3	Tower Foundation
			1			TS	Tower Sicily
				1		G1	Leg North-East
				2		G2	Leg South-West
				3		G3	Cross Beam
			2			TC	Tower Calabria
				1		G1	Leg North-East
				2		G2	Leg South-West
				3		G3	Cross Beam
		2				B4	Anchor Blocks
			1			BS	Anchor Block - Sicily
			2			BC	Anchor Block - Calabria
		3				F4	Terminal Structures Foundations
			1			VS	Terminal Structures Sicily
				1		FD	Foundation
				2		PL	Piers
			2			VC	Terminal Structures Calabria
				1		FD	Foundation
				2		PL	Piers
		4				S6	External Arrangements
			1			TS	Tower Sicily
			2			TC	Tower Calabria
			3			BS	Anchor Block - Sicily
			4			BC	Anchor Block - Calabria
			5			VS	Terminal Sructures Sicily
			6			VC	Terminal Structures Calabria
	2					SV	Superstructures
		1				T4	Towers
			1			TS	Tower Sicily
				1		G1	Leg North-East
					1	01	Segment 1
					n	nn	Segment n
					n+1	D0	Diaphragm/Stiffener
				2		G2	Leg South-West
					1	01	Segment 1
					n	nn	Segment n
					n+1	D0	Diaphragm/Stiffener
				3		TO	Cross Beams
					1	01	Cross Beam 1
					2	02	Cross Beam 2
					3	03	Cross Beam 3
					4	D0	Stiffener
			2			TC	Tower Calabria
				1		G1	Leg North-East
					1	01	Segment 1
					n	nn	Segment n
					n+1	D0	Diaphragm/Stiffener
				2		G2	Leg South-West
					1	01	Segment 1
					n	nn	Segment n
					n+1	D0	Diaphragm/Stiffener
				3		TO	Cross Beams
					1	01	Cross Beam 1
					2	02	Cross Beam 2
					3	03	Cross Beam 3
					4	D0	Stiffener
		2				S7	Suspension System
			1			CO	Cable Clamps
				1		MS	Main Span
					6	06	Cable Clamp 6
					n	nn	Cable Clamp n
				2		?	Side Span Sicily
					1	01	Cable Clamp 1
					n	nn	Cable Clamp n
				3		?	Side Span Calabria
					115	115	Cable Clamp 115
					n	nn	Cable Clamp n
			2			SL	Saddles
				1		SA	Splay Saddles
				2		ST	Tower Saddles
			3			PE	Hangers
				1		?	Main Span
					6	06	Hanger 6
					n	nn	Hanger n
				2		?	Side Span Sicily
					1	1	Hanger 1
					nn	nn	Hanger nn
				3		?	Side Span Calabria
					115	115	Hanger 115
					nn	nn	Hanger nn
			4	1		CA	Main Cables
					1	C1	Main Cable 1

Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	ID	Element
					2	C2	Main Cable 2
					3	C3	Main Cable 3
					4	C4	Main Cable 4
			5	1		?	Handstrand Ropes
					1	?	Handstrand Ropes (Main Cable 1)
					2	?	Handstrand Ropes (Main Cable 2)
					3	?	Handstrand Ropes (Main Cable 3)
					4	?	Handstrand Ropes (Main Cable 4)
		3				**I3**	**Deck**
			1			CF	Railway Girder
				1		MS	Main Span
					6	06	Segment 6
					n	nn	Segment n
					n+1	D0	Diaphragm, type 1
					n+2	?	Diaphragm, type 2
				2		?	Side Span Sicily
					0	00	Segment 0
					n	nn	Segment n
					n+1	D0	Diaphragm, type 1
					n+2	?	Diaphragm, type 2
				2		?	Side Span Calabria
					116	116	Segment 116
					n	nn	Segment n
					n+1	D0	Diaphragm, type 1
					n+2	?	Diaphragm, type 2
			2			?	Roadway Girder, direction Sicily
				1		MS	Main Span
					6	06	Segment 6
					n	nn	Segment n
					n+1	D0	Diaphragm
				2		?	Side Span Sicily
					2	02	Segment 2
					n	nn	Segment n
					n+1	D0	Diaphragm
				3		?	Side Span Calabria
					116	116	Segment 116
					n	nn	Segment n
					n+1	D0	Diaphragm
			3			?	Roadway Girder, direction Calabria
				1		MS	Main Span
					6	06	Segment 6
					n	nn	Segment n
					n+1	D0	Diaphragm
				2		?	Side Span Sicily
					2	02	Segment 2
					n	nn	Segment n
					n+1	D0	Diaphragm
				3		?	Side Span Calabria
					116	116	Segment 116
					n	nn	Segment n
					n+1	D0	Diaphragm
			4			TP	Main Cross Girders
				1		MS	Main Span
					6	06	Cross Girder 6
					n	nn	Cross Girder n
					n+1	D0	Diaphragm
				2		LS	Side Span
					1	01	Cross Girder 1
					n	nn	Cross Girder n
					n+1	D0	Diaphragm
		4				**S8**	**Terminal Structures**
			1			VS	Terminal Structures Sicily
				1		SC	Longitudinal Steel
				2		S1	Slab
				3		?	Bottom Plate
			2			VC	Terminal Structures Calabria
				1		SC	Longitudinal Steel
				2		S1	Slab
				3		?	Bottom Plate
	3					**SS**	**Secondary System**
		1				**R4**	**Secondary Structures**
			1			CR	Service Lane
				1		?	Service Lane, direction Sicily
				2		?	Service Lane, direction Calabria
			2			BF	Wind Screens
				1		?	Wind Screens, direction Sicily
				2		?	Wind Screens, direction Calabria
			3			BA	Roadway Barriers
				1		?	Roadway Barriers, direction Sicily
				2		?	Roadway Barriers, direction Calabria
			4			?	Light masts
				1		?	Light masts, direction Sicily
				2		?	Light masts, direction Calabria
			5			?	Cross Overs

Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	ID	Element
				1		?	Cross Overs, direction Sicily
				2		?	Cross Overs, direction Calabra
			6			?	Service Areas
				1		?	Service Areas, direction Sicily
				2		?	Service Areas, direction Calabria
			7			PA	Tower Gantries and Elevators
				1		?	Tower Gantries, Sicily Tower
				2		?	Tower Gantries, Calabria Tower
				3		?	Elevators, Sicily Tower
				4		?	Elevators, Calabria Tower
			8			?	Main Cables Carriages and Hanger Baskets
			9			?	Gantries for Suspended Deck
				1		?	Gantry for side span - Sicily
				2		?	Gantry for main span - Sicily
				3		?	Gantry for main span - Calabria
				4		?	Gantry for side span - Calabria
			10			DU	Dehumidification System
		2				**A0**	**Articulations**
			1			AP	Bearings
				1		?	Roadway Bearings, direction Sicily
				2		?	Roadway Bearings, direction Calabria
				3		FB	Railway Bearings
				4		?	Transverse support of suspended deck
			2			GE	Expansion Joints
				1		?	Roadway Joints, direction Sicily
				2		?	Roadway Joints, direction Calabria
				3		FJ	Railway Joints
			3			AM	Buffer
				1		?	Hydraulic Buffers - Tower
				2		?	Hydraulic Buffers - Terminal Structures
		3				**P2**	**Platform**
			1			SR	Roadway
				1		CS	Carriageway direction Sicily
					1	PV	Surfacing
					2	SG	Road Markings
				2		CC	Carriageway direction Calabria
					1	PV	Surfacing
					2	SG	Road Markings
			2			FE	Railway
				1		BP	Even track
					1	RT	Rail
					2	AM	Fastening System
					3	SV	Unscrewing System
				2		BD	Odd Track
					1	RT	Rail
					2	AM	Fastening System
					3	SV	Unscrewing System
	4					**IT**	**Technological Systems**
		1				**M3**	**Monitoring Systems**
			1			C1	Control & Monitoring System for Electric and Mechanic
			2			C2	Railway Monitoring System
			3			SM	SHMS Monitoring System
		2				**F5**	**Railway Systems**
			1			IS	Signal System
			2			TT	Telecommunication (Railway)
			3			TE	Overhead Electrics
		3				**M2**	**Mechanical and Hydraulical**
			1			DI	Water Supply
			2			AS	Surface Drainage
		4				**E2**	**Electrical Systems**
			1			SA	Lightning Conductor
			2			DE	Electric Supply MT/ST
			3			SI	Illumination System
				1		IN	Internal Illumination
				2		EX	External Illumination
				3		AN	Aviation and Navigation Warning Light
		5				**A3**	**Safety and Anti-Sabotage System (SSS)**
		6				**M4**	**Operation and Maintenance Systems**
			1			C3	Operational - Logistics MACS
			2			C4	DWPMS
			3			C5	WSMS
			4			C6	BMS (WMPS)
			5			C7	ICMS
			6			C8	EDMS
			7			C9	CSP
			8			GT	TMS Traffic Management
		7				**S9**	**Special Plants**
			1			SC	Communication System
				1		DS	Data Communication
				2		TC	Telecommunication

Appendix 4.2.D - Bridge Element Hierarchy, level 2 - 8

Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	ID	Element	Level 8	SUB-element at level 8
1						P	**Suspension Bridge**		
	1					ST	**Substructure**		
		1				F3	**Tower Foundation**		
			1			TS	Tower Sicily		
				1		G1	Leg North-East		
				2		G2	Leg South-West		
				3		G3	Cross Beam		
			2			TC	Tower Calabria		
				1		G1	Leg North-East		
				2		G2	Leg South-West		
				3		G3	Cross Beam		
		2				B4	**Anchor Blocks**		
			1			BS	Anchor Block - Sicily		
			2			BC	Anchor Block - Calabria		
		3				F4	**Terminal Structures Foundations**		
			1			VS	Terminal Structures Sicily		
				1		FD	Foundation		
				2		PL	Piers		
			2			VC	Terminal Structures Calabria		
				1		FD	Foundation		
				2		PL	Piers		
		4				S6	**External Arrangements**		
			1			TS	Tower Sicily		
			2			TC	Tower Calabria		
			3			BS	Anchor Block - Sicily		
			4			BC	Anchor Block - Calabria		
			5			VS	Terminal Structures Sicily		
			6			VC	Terminal Structures Calabria		
	2					SV	**Superstructures**		
		1				T4	**Towers**		
			1			TS	Tower Sicily		
				1		G1	Leg North-East		
					1	01	Segment 1		
						?		1	External surfaces
						?		2	Internal surfaces
						?		3	Connections to foundations
						?		4	Secondary Steel Work
					n	nn	Segment n		
						?		1	External surfaces
						?		2	Internal surfaces
						?		4	Secondary Steel Work
					n+1	D0	Diaphragm/Stiffener		
				2		G2	Leg South-West		
					1	01	Segment 1		SUB-elements like Segment 1
					n	nn	Segment n		SUB-elements like segment n
					n+1	D0	Diaphragm/Stiffener		
				3		TO	Cross Beams		
					1	01	Cross Beam 1		
						?		1	External surfaces
						?		2	Internal surfaces
						?		4	Secondary Steel Work
					2	02	Cross Beam 2		SUB-elements like Cross Beam 1
					3	03	Cross Beam 3		SUB-elements like Cross Beam 1
					4	D0	Stiffener		
			2			TC	Tower Calabria		
				1		G1	Leg North-East		
					1	01	Segment 1		SUB-elements like Segment 1
					n	nn	Segment n		SUB-elements like segment n
					n+1	D0	Diaphragm/Stiffener		
				2		G2	Leg South-West		
					1	01	Segment 1		SUB-elements like Segment 1
					n	nn	Segment n		SUB-elements like segment n
					n+1	D0	Diaphragm/Stiffener		
				3		TO	Cross Beams		
					1	01	Cross Beam 1		SUB-elements like Cross Beam 1
					2	02	Cross Beam 2		SUB-elements like Cross Beam 1
					3	03	Cross Beam 3		SUB-elements like Cross Beam 1
					4	D0	Stiffener		
		2				S7	**Suspension System**		
			1			CO	Cable Clamps		
				1		MS	Main Span		
					6	06	Cable Clamp 6		
						?		1	Cable clamp castings
						?		2	Cable clamp bolts
						?		3	Cable clamp seals
					n	nn	Cable Clamp n		SUB-elements like Cable Clamp 6
				2		?	Side Span Sicily		
					1	01	Cable Clamp 1		SUB-elements like Cable Clamp 6
					n	nn	Cable Clamp n		SUB-elements like Cable Clamp 6
				3		?	Side Span Calabria		
					115	115	Cable Clamp 115		SUB-elements like Cable Clamp 6
					n	nn	Cable Clamp n		SUB-elements like Cable Clamp 6
			2			SL	Saddles		
				1		SA	Splay Saddles		
				2		ST	Tower Saddles		
			3			PE	Hangers		
				1		?	Main Span		
					6	06	Hanger 6		
						?		1	HDPE Sheats
						?		2	Steel wires
						?		3	Hanger sockets
						?		4	Upper connections
						?		5	Lower connections
						?		6	Dampers / Spacers
					n	nn	Hanger n		SUB-elements like Hanger 6
				2		?	Side Span Sicily		
					1	1	Hanger 1		SUB-elements like Hanger 6
					nn	nn	Hanger nn		SUB-elements like Hanger 6
				3		?	Side Span Calabria		
					115	115	Hanger 115		SUB-elements like Hanger 6
					nn	nn	Hanger nn		SUB-elements like Hanger 6
			4	1		CA	Main Cables		
					1	C1	Main Cable 1		
						?		1	Main cable
						?		2	Main cable (inside anchor blocks))
						?		3	Neoprene wrapping

Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	ID	Element	Level 8	SUB-element at level 8
						?		4	Cross head plate (inside anchor blocks)
						?		5	Anchor rods M 130 (inside anchor blocks)
						?		6	Upper anchor plate (inside anchor blocks)
						?		7	Anchor bolts M 64 (inside anchor bolts)
								8	Secondary Steel Work
					2	C2	Main Cable 2		SUB-elements like Main Cable 1
					3	C3	Main Cable 3		SUB-elements like Main Cable 1
					4	C4	Main Cable 4		SUB-elements like Main Cable 1
			5	1		?	Handstrand Ropes		
					1	?	Handstrand Ropes (Main Cable 1)		
						?		1	Outer Handstrand rope
						?		2	Inner Handstrand rope
						?		3	Support posts and clamps
						?		4	Rope anchorages - Deck level
						?		5	Rope anchorages - Tower tops
					2	?	Handstrand Ropes (Main Cable 2)		SUB-elements like Handstrand Ropes (Main Cable 1)
					3	?	Handstrand Ropes (Main Cable 3)		SUB-elements like Handstrand Ropes (Main Cable 1)
					4	?	Handstrand Ropes (Main Cable 4)		SUB-elements like Handstrand Ropes (Main Cable 1)
		3				I3	**Deck**		
			1			CF	Railway Girder		
				1		MS	Main Span		
					6	06	Segment 6		
						?		1	External surfaces
						?		2	Internal surfaces
						?		3	T-beams below the tracks
						?		4	Troughs below deck plate
						?		5	Secondary Steel Work
					n	nn	Segment n		SUB-elements like segment 6 (railway girder)
					n+1	D0	Diaphragm, type 1		
					n+2	?	Diaphragm, type 2		
				2		?	Side Span Sicily		
					0	00	Segment 0		SUB-elements like segment 6 (railway girder)
					n	nn	Segment n		SUB-elements like segment 6 (railway girder)
					n+1	D0	Diaphragm, type 1		
					n+2	?	Diaphragm, type 2		
				3		?	Side Span Calabria		
					116	116	Segment 116		SUB-elements like segment 6 (railway girder)
					n	nn	Segment n		SUB-elements like segment 6 (railway girder)
					n+1	D0	Diaphragm, type 1		
					n+2	?	Diaphragm, type 2		
			2			?	Roadway Girder, direction Sicily		
				1		MS	Main Span		
					6	06	Segment 6		
						?		1	External surfaces
						?		2	Internal surfaces
						?		3	Troughs below deck plate
						?		5	Secondary Steel Work
					n	nn	Segment n		SUB-elements like segment 6 (roadway girder)
					n+1	D0	Diaphragm		
				2		?	Side Span Sicily		
					2	02	Segment 2		SUB-elements like segment 6 (roadway girder)
					n	nn	Segment n		SUB-elements like segment 6 (roadway girder)
					n+1	D0	Diaphragm		
				3		?	Side Span Calabria		
					116	116	Segment 116		SUB-elements like segment 6 (roadway girder)
					n	nn	Segment n		SUB-elements like segment 6 (roadway girder)
					n+1	D0	Diaphragm		
			3			?	Roadway Girder, direction Calabra		
				1		MS	Main Span		
					6	06	Segment 6		SUB-elements like segment 6 (roadway girder)
					n	nn	Segment n		SUB-elements like segment 6 (roadway girder)
					n+1	D0	Diaphragm		
				2		?	Side Span Sicily		
					2	02	Segment 2		SUB-elements like segment 6 (roadway girder)
					n	nn	Segment n		SUB-elements like segment 6 (roadway girder)
					n+1	D0	Diaphragm		
				3		?	Side Span Calabria		
					116	116	Segment 116		SUB-elements like segment 6 (roadway girder)
					n	nn	Segment n		SUB-elements like segment 6 (roadway girder)
					n+1	D0	Diaphragm		
			4			TP	Main Cross Girders		
				1		MS	Main Span		
					6	06	Cross Girder 6		
					n	nn	Cross Girder n		
					n+1	D0	Diaphragm		
				2		LS	Side Span		
					1	01	Cross Girder 1		
					n	nn	Cross Girder n		
					n+1	D0	Diaphragm		
		4				S8	**Terminal Structures**		
			1			VS	Terminal Structures Sicily		
				1		SC	Longitudinal Steel		
						?		1	External surfaces
						?		2	Internal surfaces
				2		S1	Slab		
				3		?	Bottom Plate		
			2			VC	Terminal Structures Calabria		
				1		SC	Longitudinal Steel		SUB-elements like Longitudinal Steel (Terminal Structures Sicily)
				2		S1	Slab		
				3		?	Bottom Plate		
	3					SS	**Secondary System**		
		1				R4	**Secondary Structures**		
			1			CR	Service Lane		
				1		?	Service Lane, direction Sicily		
				2		?	Service Lane, direction Calabria		
			2			BF	Wind Screens		
				1		?	Wind Screens, direction Sicily		
				2		?	Wind Screens, direction Calabria		
			3			BA	Roadway Barriers		
				1		?	Roadway Barriers, direction Sicily		
				2		?	Roadway Barriers, direction Calabria		
			4			?	Light masts		
				1		?	Light masts, direction Sicily		
				2		?	Light masts, direction Calabria		
			5			?	Cross Overs		
				1		?	Cross Overs, direction Sicily		

Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	ID	Element	Level 8	SUB-element at level 8
				2		?	Cross Overs, direction Calabra		
			6			?	Service Areas		
				1		?	Service Areas, direction Sicily		
				2		?	Service Areas, direction Calabria		
			7			PA	Tower Gantries and Elevators		
				1		?	Tower Gantries, Sicily Tower		
				2		?	Tower Gantries, Calabria Tower		
				3		?	Elevators, Sicily Tower		
				4		?	Elevators, Calabria Tower		
			8			?	Main Cables Carriages and Hanger Baskets		
			9			?	Gantries for Suspended Deck		
				1		?	Gantry for side span - Sicily		
				2		?	Gantry for main span - Sicily		
				3		?	Gantry for main span - Calabria		
				4		?	Gantry for side span - Calabria		
			10			DU	Dehumidification System		
		2				**A0**	**Articulations**		
			1			AP	Bearings		
				1		?	Roadway Bearings, direction Sicily		
				2		?	Roadway Bearings, direction Calabria		
				3		FB	Railway Bearings		
				4		?	Transverse support of suspended deck		
			2			GE	Expansion Joints		
				1		?	Roadway Joints, direction Sicily		
				2		?	Roadway Joints, direction Calabria		
				3		FJ	Railway Joints		
			3			AM	Buffer		
				1		?	Hydraulic Buffers - Tower		
				2		?	Hydraulic Buffers - Terminal Structures		
		3				**P2**	**Platform**		
			1			SR	Roadway		
				1		CS	Carriageway direction Sicily		
					1	PV	Surfacing		
					2	SG	Road Markings		
				2		CC	Carriageway direction Calabria		
					1	PV	Surfacing		
					2	SG	Road Markings		
			2			FE	Railway		
				1		BP	Even track		
					1	RT	Rail		
					2	AM	Fastening System		
					3	SV	Unscrewing System		
				2		BD	Odd Track		
					1	RT	Rail		
					2	AM	Fastening System		
					3	SV	Unscrewing System		
	4					**IT**	**Technological Systems**		
		1				**M3**	**Monitoring Systems**		
			1			C1	Control & Monitoring System for Electric and Mechanic		
			2			C2	Railway Monitoring System		
			3			SM	SHMS Monitoring System		
		2				**F5**	**Railway Systems**		
			1			IS	Signal System		
			2			TT	Telecommunication (Railway)		
			3			TE	Overhead Electrics		
		3				**M2**	**Mechanical and Hydraulical**		
			1			DI	Water Supply		
			2			AS	Surface Drainage		
		4				**E2**	**Electrical Systems**		
			1			SA	Lightning Conductor		
			2			DE	Electric Supply MT/ST		
			3			SI	Illumination System		
				1		IN	Internal Illumination		
				2		EX	External Illumination		
				3		AN	Aviation and Navigation Warning Light		
		5				**A3**	**Safety and Anti-Sabotage System (SSS)**		
		6				**M4**	**Operation and Maintenance Systems**		
			1			C3	Operational - Logistics MACS		
			2			C4	DWPMS		
			3			C5	WSMS		
			4			C6	BMS (WMPS)		
			5			C7	ICMS		
			6			C8	EDMS		
			7			C9	CSP		
			8			GT	TMS Traffic Management		
		7				**S9**	**Special Plants**		
			1			SC	Communication System		
				1		DS	Data Communication		
				2		TC	Telecommunication		

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Appendix 4.2.E - Location Codes, level 2 - 7

								Element location codes					
								Code 1	Code 2	Code 3	Code 4	Code 5	Code 6
Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	ID	Element	Start St.	End St.	Element no.	Orientation of face	Level	Position on face
1						P	Suspension Bridge						
	1					ST	Substructure						
		1				F3	Tower Foundation						
			1			TS	Tower Sicily						
				1		G1	Leg North-East						
				2		G2	Leg South-West						
				3		G3	Cross Beam						
			2			TC	Tower Calabria						
				1		G1	Leg North-East						
				2		G2	Leg South-West						
				3		G3	Cross Beam						
		2				B4	Anchor Blocks						
			1			BS	Anchor Block - Sicily			E/W			
			2			BC	Anchor Block - Calabria			E/W			
		3				F4	Terminal Structures Foundations						
			1			VS	Terminal Structures Sicily						
				1		FD	Foundation			Pier no.			
				2		PL	Piers			Pier no.			
			2			VC	Terminal Structures Calabria						
				1		FD	Foundation			Pier no.			
				2		PL	Piers			Pier no.			
		4				S6	External Arrangements						
			1			TS	Tower Sicily						
			2			TC	Tower Calabria						
			3			BS	Anchor Block - Sicily			E/W			
			4			BC	Anchor Block - Calabria			E/W			
			5			VS	Terminal Sructures Sicily			Pier no.			
			6			VC	Terminal Structures Calabria			Pier no.			
	2					SV	Superstructures						
		1				T4	Towers						
			1			TS	Tower Sicily						
				1		G1	Leg North-East						
					1	01	Segment 1			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm/Stiffener			Segment and cell no.			
				2		G2	Leg South-West						
					1	01	Segment 1			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm/Stiffener			Segment and cell no.			
				3		TO	Cross Beams						
					1	01	Cross Beam 1			Cell no.			
					2	02	Cross Beam 2			Cell no.			
					3	03	Cross Beam 3			Cell no.			
					4	D0	Stiffener			Cross Beam and Stiffener no.			
			2			TC	Tower Calabria						
				1		G1	Leg North-East						
					1	01	Segment 1			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm/Stiffener			Segment and cell no.			
				2		G2	Leg South-West						
					1	01	Segment 1			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm/Stiffener			Segment and cell no.			
				3		TO	Cross Beams						
					1	01	Cross Beam 1			Cell no.			
					2	02	Cross Beam 2			Cell no.			
					3	03	Cross Beam 3			Cell no.			
					4	D0	Stiffener			Cross Girder and Stiffener no.			
		2				S7	Suspension System						
			1			CO	Cable Clamps						
				1		MS	Main Span						
					6	06	Cable Clamp 6			6.E.N / 6.E.S / 6.W.N / 6.W.S			
					n	nn	Cable Clamp n			n.E.N / n.E.S / n.W.N / n.W.S			
				2		?	Side Span Sicily						
					1	01	Cable Clamp 1			1.E.N / 1.E.S / 1.W.N / 1.W.S			
					n	nn	Cable Clamp n			n.E.N / n.E.S / n.W.N / n.W.S			
				3		?	Side Span Calabria						
					1	115	Cable Clamp 115			115.E.N / 115.E.S / 115.W.N / 115.W.S			
					n	nn	Cable Clamp n			n.E.N / n.E.S / n.W.N / n.W.S			
			2			SL	Saddles						
				1		SA	Splay Saddles			S.E / S.W / C.E / C.W			
				2		ST	Tower Saddles			S.E / S.W / C.E / C.W			
			3			PE	Hangers						
				1		?	Main Span						
					6	6	Hanger 6			6.E.N / 6.E.S / 6.W.N / 6.W.S			
					n	nn	Hanger nn			n.E.N / n.E.S / n.W.N / n.W.S			
				2		?	Side Span Sicily						
					1	1	Hanger 1			1.E.N / 1.E.S / 1.W.N / 1.W.S			
					nn	nn	Hanger nn			n.E.N / n.E.S / n.W.N / n.W.S			
				3		?	Side Span Calabria						
					115	115	Hanger 115			115.E.N / 115.E.S / 115.W.N / 115.W.S			
					n	nn	Hanger n			n.E.N / n.E.S / n.W.N / n.W.S			
			4	1		CA	Main Cables						
					1	C1	Main Cable 1			Cable Clamp No.			
					2	C2	Main Cable 2			Cable Clamp No.			
					3	C3	Main Cable 3			Cable Clamp No.			
					4	C4	Main Cable 4			Cable Clamp No.			
			5	1		?	Handstrand Ropes						
					1	?	Handstrand Ropes (Main Cable 1)			Hanger no.			
					2	?	Handstrand Ropes (Main Cable 2)			Hanger no.			
					3	?	Handstrand Ropes (Main Cable 3)			Hanger no.			
					4	?	Handstrand Ropes (Main Cable 4)			Hanger no.			
		3				I3	Deck						
			1			CF	Railway Girder						
				1		MS	Main Span						
					6	06	Segment 6			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm, type 1			Segment and Diaphragm no.			
					n+2	?	Diaphragm, type 2			Segment and Diaphragm no.			
				2		?	Side Span Sicily						
					0	00	Segment 0			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm, type 1			Segment and Diaphragm no.			
					n+2	?	Diaphragm, type 2			Segment and Diaphragm no.			
				3		?	Side Span Calabria						
					116	116	Segment 116			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm, type 1			Segment and Diaphragm no.			
					n+2	?	Diaphragm, type 2			Segment and Diaphragm no.			
			2			?	Roadway Girder, direction Sicily						
				1		MS	Main Span						
					6	06	Segment 6			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm			Segment and Diaphragm no.			
				2		?	Side Span Sicily						
					2	02	Segment 2			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm			Segment and Diaphragm no.			
				3		?	Side Span Calabria						
					116	116	Segment 116			Cell no.			
					n	nn	Segment n			Cell no.			

								Element location codes					
								Code 1	Code 2	Code 3	Code 4	Code 5	Code 6
Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	ID	Element	Start St.	End St.	Element no.	Orientation of face	Level	Position on face
					n+1	D0	Diaphragm			Segment and Diaphragm no.			
			3			?	Roadway Girder, direction Calabria						
				1		MS	Main Span						
					6	06	Segment 6			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm			Segment and Diaphragm no.			
				2		?	Side Span Sicily						
					2	02	Segment 2			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm			Segment and Diaphragm no.			
				3		?	Side Span Calabria						
					116	116	Segment 116			Cell no.			
					n	nn	Segment n			Cell no.			
					n+1	D0	Diaphragm			Segment and Diaphragm no.			
			4			TP	Main Cross Girders						
				1		MS	Main Span						
					6	06	Cross Girder 6			Diaphragm no.			
					n	nn	Cross Girder n			Diaphragm no.			
					n+1	D0	Diaphragm			Girder and diaphragm no.			
				2		LS	Side Span						
					1	01	Cross Girder 1			Diaphragm no.			
					n	nn	Cross Girder n			Diaphragm no.			
					n+1	D0	Diaphragm			Girder and diaphragm no.			
		4				**S8**	**Terminal Structures**						
			1			VS	Terminal Structures Sicily						
				1		SC	Longitudinal Steel			Beam no.			
				2		S1	Slab			Field no.			
				3		?	Bottom Plate			Field no.			
			2			VC	Terminal Structures Calabria						
				1		SC	Longitudinal Steel			Beam no.			
				2		S1	Slab			Field no.			
				3		?	Bottom Plate			Field no.			
	3					**SS**	**Secondary System**						
		1				**R4**	**Secondary Structures**						
			1			CR	Service Lane						
				1		?	Service Lane, direction Sicily						
				2		?	Service Lane, direction Calabria						
			2			BF	Wind Screens						
				1		?	Wind Screens, direction Sicily						
				2		?	Wind Screens, direction Calabria						
			3			BA	Roadway Barriers						
				1		?	Roadway Barriers, direction Sicily						
				2		?	Roadway Barriers, direction Calabria						
			4			?	Light masts						
				1		?	Light masts, direction Sicily						
				2		?	Light masts, direction Calabria						
			5			?	Cross Overs						
				1		?	Cross Overs, direction Sicily						
				2		?	Cross Overs, direction Calabra						
			6			?	Service Areas						
				1		?	Service Areas, direction Sicily						
				2		?	Service Areas, direction Calabria						
			7			PA	Tower Gantries and Elevators						
				1		?	Tower Gantries, Sicily Tower						
				2		?	Tower Gantries, Calabria Tower						
				3		?	Elevators, Sicily Tower						
				4		?	Elevators, Calabria Tower						
			8			?	Main Cables Carriages and Hanger Baskets			SW / MSSW / MSCW / CW / SE / MSSE / MSCE / CE			
			9			?	Gantries for Suspended Deck						
				1		?	Gantry for side span - Sicily						
				2		?	Gantry for main span - Sicily						
				3		?	Gantry for main span - Calabria						
				4		?	Gantry for side span - Calabria						
			10			DU	Dehumidification System			Plant no.			
		2				**A0**	**Articulations**						
			1			AP	Bearings						
				1		?	Roadway Bearings, direction Sicily			Bearing type and S/C			
				2		?	Roadway Bearings, direction Calabria			Bearing type and S/C			
				3		FB	Railway Bearings			Bearing type, E/W and S/C			
				4		?	Transverse support of suspended deck			Gridline			
			2			GE	Expansion Joints						
				1		?	Roadway Joints, direction Sicily			Expansion Joint type and S/C			
				2		?	Roadway Joints, direction Calabria			Expansion Joint type and S/C			
				3		FJ	Railway Joints			Expansion Joint type and S/C			
			3			AM	Buffer						
				1		?	Hydraulic Buffers - Tower			Buffer type and E/W (E/W only for buffer type D2)			
				2		?	Hydraulic Buffers - Terminal Structures			Buffer type and gridline			
		3				**P2**	**Platform**						
			1			SR	Roadway						
				1		CS	Carriageway direction Sicily						
					1	PV	Surfacing			Lane no.			
					2	SG	Road Markings			Lane no.			
				2		CC	Carriageway direction Calabria						
					1	PV	Surfacing			Lane no.			
					2	SG	Road Markings			Lane no.			
			2			FE	Railway						
				1		BP	Even track						
					1	RT	Rail						
					2	AM	Fastening System						
					3	SV	Unscrewing System						
				2		BD	Odd Track						
					1	RT	Rail						
					2	AM	Fastening System						
					3	SV	Unscrewing System						

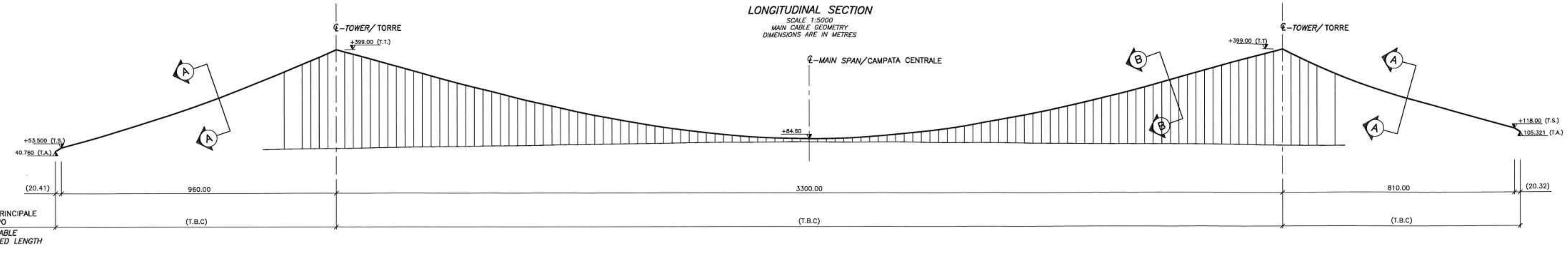
No information to be inserted in shaded cells

Rev. 2, 31-08-2010

Appendix 4.2.F - Reference drawing, Main Cables

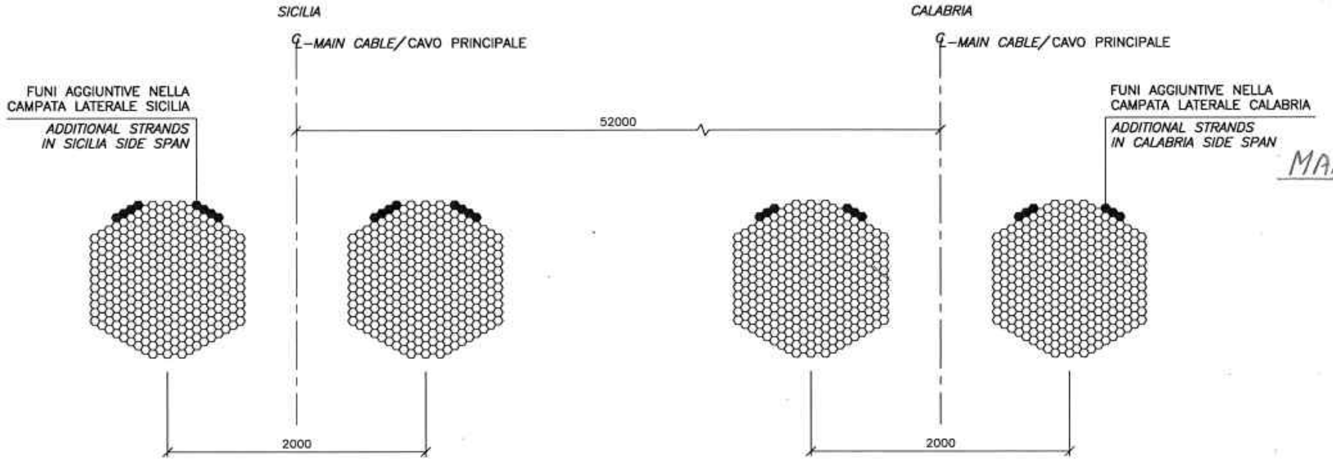
SEZIONE LONGITUDINALE
SCALA 1:5000
GEOMETRIA CAVO PRINCIPALE
LE DIMENSIONI SONO IN M

LONGITUDINAL SECTION
SCALE 1:5000
MAIN CABLE GEOMETRY
DIMENSIONS ARE IN METRES



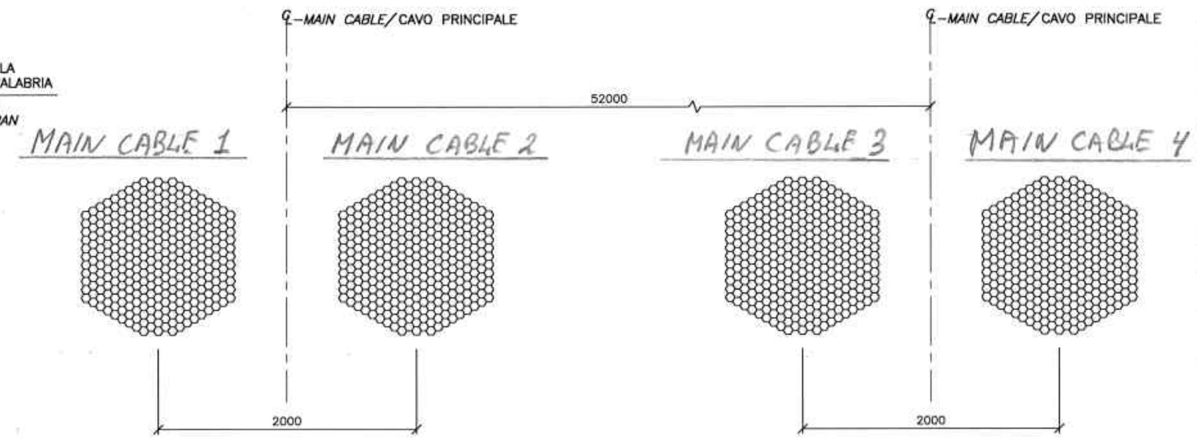
SEZIONE A–A
SCALA 1:20
CAMPATA LATERALE

SECTION A–A
SCALE 1:20
SIDE SPANS



SEZIONE B–B
SCALA 1:20
CAMPATA CENTRALE

SECTION B–B
SCALE 1:20
MAIN SPAN



NOTE:

DIMENSIONI:	TUTTE LE DIMENSIONI SONO IN MILLIMETRI, SALVO OVE DIVERSAMENTE INDICATO. LE QUOTE ALTIMETRICHE SONO IN METRI.
MATERIALI:	CAVO PRINCIPALE fu=1860 MPa

LEGENDA:

T.T.	PUNTO DI INTERSEZIONE TEORICA DEI CAVI NELLE SELLE
T.S.	PUNTO DI DEVIAZIONE TEORICA DEI CAVI NEI PETTINI DI DEVIAZIONE
T.A.	PUNTO DI ANCORAGGIO TEORICO DEI CAVI

NOTES:

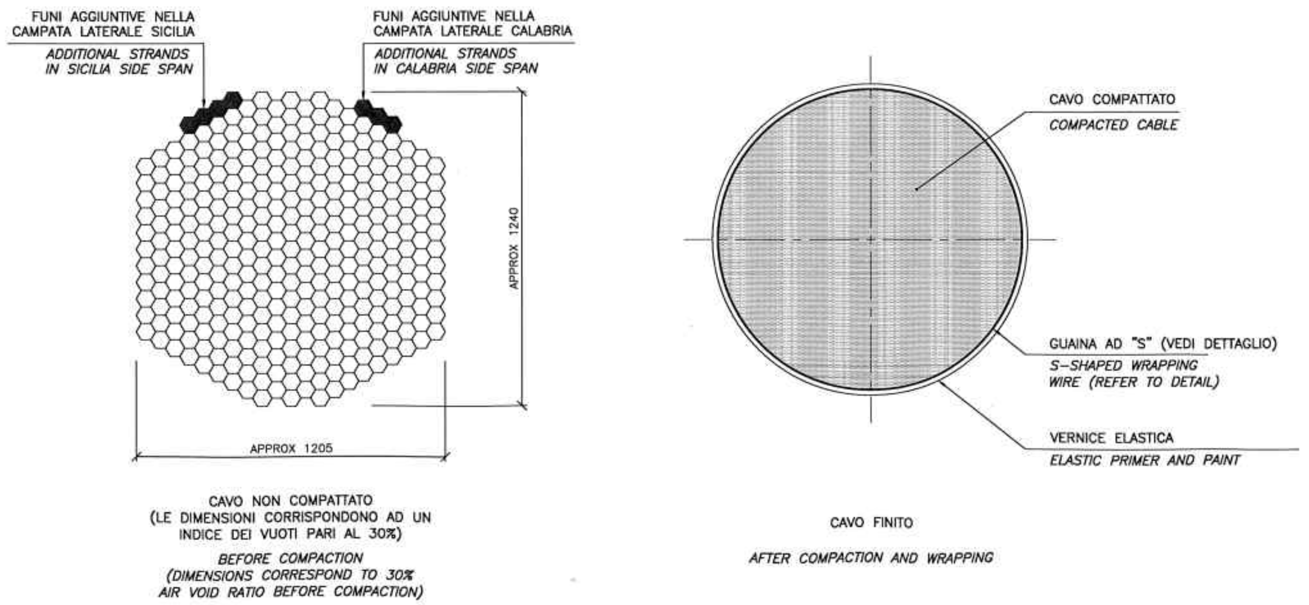
DIMENSIONS:	*DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED. LEVELS ARE IN METRES*
ERECTION:	*PREFORMED PARALLEL WIRE STRAND (PPWS) (UNI EN 12385, UNI EN 13411)*
MATERIALS:	*MAIN CABLE: CLASS A GALVANISED WIRE (UNI EN 10264) MIN fu = 1860 MPa WIRE WRAPPING: SOFT ANNEALED GALVANISED S-SHAPED WRAPPING WIRE (BS 1052) ALL WIRES GALVANISED TO MIN 300 g/m² (UNI EN 10244)*

LEGEND:

T.T	*THEORETICAL CABLE POINT AT TOWER SADDLE*
T.S.	*THEORETICAL CABLE POINT AT SPLAY SADDLE*
T.A.	*THEORETICAL CABLE POINT AT ANCHORAGE*

SEZIONE DEL CAVO
SCALA 1:10

MAIN CABLE SECTIONS
SCALE 1:10



CAVO NON COMPATTATO
(LE DIMENSIONI CORRISPONDONO AD UN INDICE DEI VUOTI PARI AL 30%)
BEFORE COMPACTION
(DIMENSIONS CORRESPOND TO 30% AIR VOID RATIO BEFORE COMPACTION)

CAVO FINITO
AFTER COMPACTION AND WRAPPING

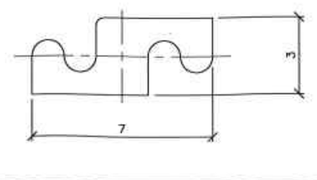
DIMENSIONI E GEOMETRIA DEL CAVO PRINCIPALE
MAIN CABLE DIMENSIONS AND GEOMETRY

	CAMPATA CENTRALE *MAIN SPAN*	CAMPATA LATERALE SICILIA *SICILIA SIDE SPAN*	CAMPATA LATERALE CALABRIA *CALABRIA SIDE SPAN*
N. DI FUNI *NO. OF STRANDS*	325	333	331
N. DI FILI PER FUNE *NO. OF WIRES PER STRAND*	127	127	127
DIAMETRO FILO (mm) *WIRE DIAMETER* (mm)	5.32	5.32	5.32
N. TOTALE FILI PER 1 DEI 4 CAVI *NUMBER OF WIRES/CABLE (4 CABLES)*	41275	42291	42037
AREA DI CIASCUNO DEI QUATTRO CAVI (m²) *CABLE CROSS–SECTIONAL AREA* (m²)	0.917	0.940	0.934
DIAMETRO DI CIASCUN CAVO ESCLUSO AVVOLGIMENTO (m²) *COMPACTED CABLE DIAMETER EXCL. WRAP PING WIRE* (m)	1.201	1.216	1.212

1) DIAMETRI CORRISPONDONO AD UNA PERCENTUALE DEI VUOTI PARI AL 19 %
1) DIAMETERS CORRESPOND TO 19% AIR VOID RATIO AFTER COMPACTION

DETTAGILO DELLA GUAINA AD "S"
SCALA 10:1

S–SHAPED WRAPPING WIRE
SCALE 10:1



Stretto di Messina

Eurolink

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

IL PROGETTISTA / PROJECT MANAGER	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE	IL CONTRAENTE GENERALE / PROJECT MANAGER	STRETTO DI MESSINA
(Ing. E.M. Veje) COWI	(Dott. Ing..........)	(Ing. P.P. Marcheselli)	
DATA	DATA	DATA	DATA

OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
SISTEMA DI SOSPENSIONE
CAVO PRINCIPALE – ASSIEME

CODICE C G 1 0 0 0 P A X D P C G S S C A 0 0 0 0 0 0 0 1 A SCALA VARIE

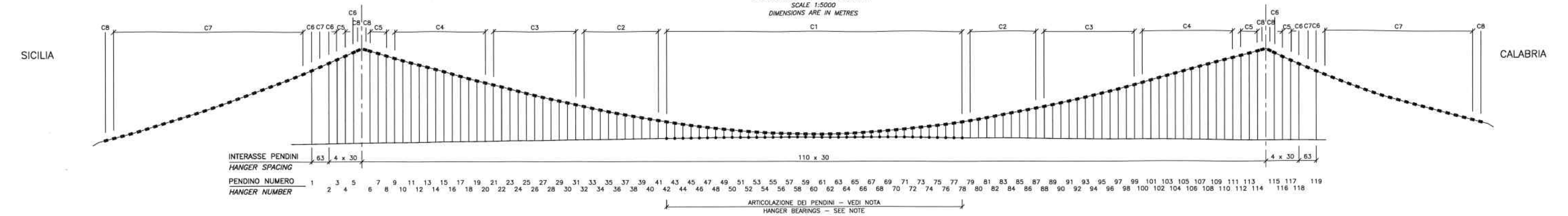
REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	20-07-2010	EMISSIONE	KMR/CWRX	IFTX	CWRX/LSJ

NOME DEL FILE: CG1000-PAXDPCG-SSCA0000000-01

Appendix 4.2.G - Reference drawing, Hangers and Cable Clamps

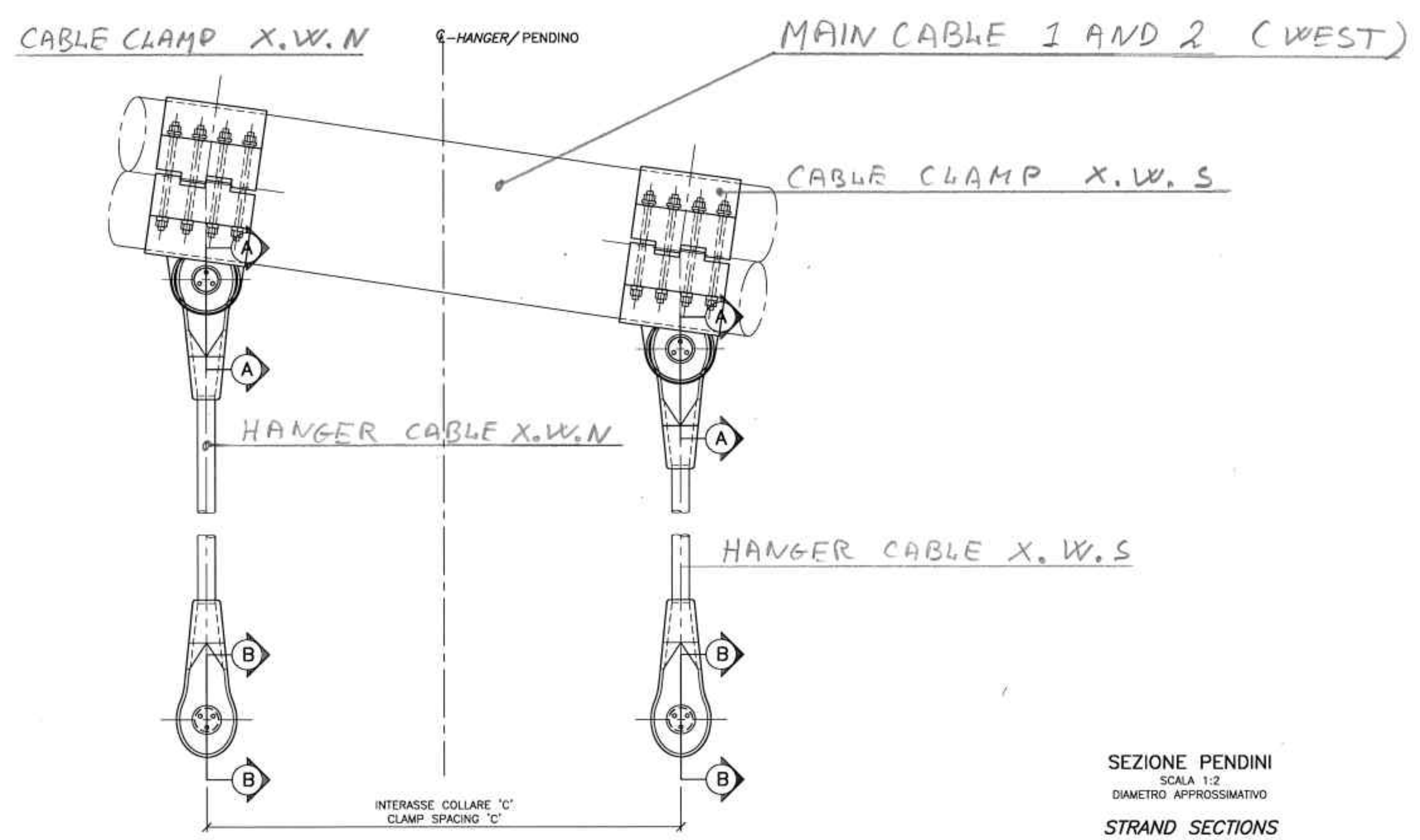
SEZIONE LONGITUDINALE
SCALA 1:5000
DIMENSIONI IN METRI

LONGITUDINAL SECTION
SCALE 1:5000
DIMENSIONS ARE IN METRES



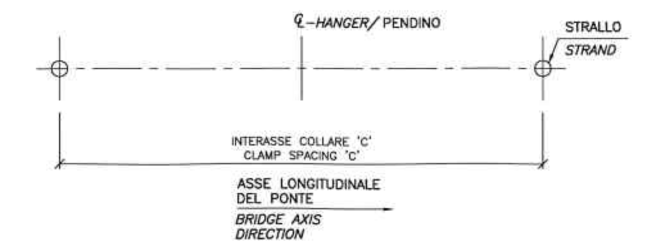
PROSPETTO PENDINI
SCALA 1:20

HANGER ELEVATION
SCALE 1:20



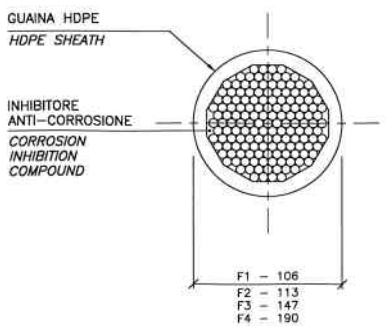
SEZIONE PENDINI
SCALA 1:20

HANGER SECTION
SCALE 1:20



SEZIONE PENDINI
SCALA 1:2
DIAMETRO APPROSSIMATIVO

STRAND SECTIONS
SCALE 1:2
DIAMETERS ARE APPROXIMATE



HANGER & CABLE CLAMP DATA

PENDINO *HANGER No.*	TIPO DI PENDINO *HANGER TYPE*	TIPO DI COLLARE *CLAMP TYPE*	NUMERO DI COLLARI *No. OF CLAMPS*	INTERASSE DEI COLLARI *CLAMP SPACING "C" (mm)*	TIPO DI TREFOLO *STRAND TYPE*	NUMERO DI TREFOLI *No. OF STRANDS*	AREA (mm²) *STRAND AREA (mm²)*	CARICO DI ROTTURA (MN) *STRAND CHARACTERISTIC BREAKING LOAD (MN)*
CAMPATA LATERALE SICILIA *SICILIA SIDE SPAN*								
1	P5	C6	2	6000	F4	2	19204	34.00
2	P5	C6	2	6000	F4	2	19204	34.00
3	P4	C5	2	3750	F3	2	10198	18.10
4	P4	C5	2	3750	F3	2	10198	18.10
5	P5	C6	2	5250	F4	2	19204	34.00
CAMPATA CENTRALE *MAIN SPAN*								
6, 114	P4	C5	2	5250	F3	2	10198	18.10
7, 113	P4	C5	2	3750	F3	2	10198	18.10
8, 112	P4	C5	2	3750	F3	2	10198	18.10
9, 111	P3	C4	2	3750	F2	2	6273	11.10
10, 110	P3	C4	2	3750	F2	2	6273	11.10
11, 109	P3	C4	2	3750	F2	2	6273	11.10
12, 108	P3	C4	2	3750	F2	2	6273	11.10
13, 107	P3	C4	2	3750	F2	2	6273	11.10
14, 106	P3	C4	2	3750	F2	2	6273	11.10
15, 105	P3	C4	2	3750	F2	2	6273	11.10
16, 104	P3	C4	2	3750	F2	2	6273	11.10
17, 103	P3	C4	2	3750	F2	2	6273	11.10
18, 102	P3	C4	2	3750	F2	2	6273	11.10
19, 101	P3	C4	2	3750	F2	2	6273	11.10
20, 100	P3	C4	2	3750	F2	2	6273	11.10
21, 99	P2	C3	2	3750	F1	2	5349	9.50
22, 98	P2	C3	2	3750	F1	2	5349	9.50
23, 97	P2	C3	2	3750	F1	2	5349	9.50
24, 96	P2	C3	2	3750	F1	2	5349	9.50
25, 95	P2	C3	2	3750	F1	2	5349	9.50
26, 94	P2	C3	2	3750	F1	2	5349	9.50
27, 93	P2	C3	2	3750	F1	2	5349	9.50
28, 92	P2	C3	2	3750	F1	2	5349	9.50
29, 91	P2	C3	2	3750	F1	2	5349	9.50
30, 90	P2	C3	2	3750	F1	2	5349	9.50
31, 89	P2	C3	2	3750	F1	2	5349	9.50
32, 88	P2	C3	2	3750	F1	2	5349	9.50
33, 87	P2	C2	2	3750	F1	2	5349	9.50
34, 86	P2	C2	2	3750	F1	2	5349	9.50
35, 85	P2	C2	2	3750	F1	2	5349	9.50
36, 84	P2	C2	2	3750	F1	2	5349	9.50
37, 83	P2	C2	2	3750	F1	2	5349	9.50
38, 82	P2	C2	2	3750	F1	2	5349	9.50
39, 81	P2	C2	2	3750	F1	2	5349	9.50
40, 80	P2	C2	2	3750	F1	2	5349	9.50
41, 79	P2	C2	2	3750	F1	2	5349	9.50
42, 78	P1	C1	2	3750	F1	2	5349	9.50
43, 77	P1	C1	2	3750	F1	2	5349	9.50
44, 76	P1	C1	2	3750	F1	2	5349	9.50
45, 75	P1	C1	2	3750	F1	2	5349	9.50
46, 74	P1	C1	2	3750	F1	2	5349	9.50
47, 73	P1	C1	2	3750	F1	2	5349	9.50
48, 72	P1	C1	2	3750	F1	2	5349	9.50
49, 71	P1	C1	2	3750	F1	2	5349	9.50
50, 70	P1	C1	2	3750	F1	2	5349	9.50
51, 69	P1	C1	2	3750	F1	2	5349	9.50
52, 68	P1	C1	2	3750	F1	2	5349	9.50
53, 67	P1	C1	2	3750	F1	2	5349	9.50
54, 66	P1	C1	2	3750	F1	2	5349	9.50
55, 65	P1	C1	2	3750	F1	2	5349	9.50
56, 64	P1	C1	2	3750	F1	2	5349	9.50
57, 63	P1	C1	2	3750	F1	2	5349	9.50
58, 62	P1	C1	2	3750	F1	2	5349	9.50
59, 61	P1	C1	2	3750	F1	2	5349	9.50
60	P1	C1	2	3750	F1	2	5349	9.50
CAMPATA LATERALE CALABRIA *CALABRIA SIDE SPAN*								
115	P5	C6	2	5250	F4	2	19204	34.00
116	P4	C5	2	3750	F3	2	10198	18.10
117	P4	C5	2	3750	F3	2	10198	18.10
118	P5	C6	2	6000	F4	2	19204	34.00
119	P5	C6	2	6000	F4	2	19204	34.00

NOTES:

DIMENSIONS: DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED. LEVELS ARE IN METRES

HANGER SYSTEM: PARALLEL WIRE STRAND, MIN fu = 1770 MPa WITH CORROSION INHIBITION COMPOUND AND EXTRUDED HDPE SHEATH (UNI EN 12385 AND UNI EN 13411)

MATERIALS: HANGERS: CLASS A GALVANISED WIRE (UNI EN 10264) MIN. fu = 1770 MPa
ALL WIRES GALVANISED TO MIN 300g/m² (UNI EN 10244)
CABLE CLAMPS: CAST STEEL GRADE G24Mn6+QT2 (1.1118) (UNI EN 10340)

VIBRATION MITIGATION: ADDITIONAL DAMPING REQUIREMENTS TO BE CONFIRMED.

HANGER BEARINGS: SPHERICAL BEARING AT DECK ANCHORAGE SHALL ALLOW ANGULAR ROTATIONS OF ±18° LONGITUDINALLY AND ±8° TRANSVERSELY. CYLINDRICAL BUSHING AT CABLE CLAMP SHALL ALLOW ANGULAR ROTATIONS OF ±18° LONGITUDINALLY ONLY.

REFERENCES:

CG1000–PAXDPCG–S5PE000000–02 HANGERS – DETAILS 1

Stretto di Messina

Euro Link

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a.r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

IL PROGETTISTA PROJECT MANAGER (Ing. E.M. Veje) COWI	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE (Dott. Ing.........)	IL CONTRAENTE GENERALE PROJECT MANAGER (Ing. P.P. Marcheselli)	STRETTO DI MESSINA
DATA	DATA	DATA	DATA

OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
SISTEMA DI SOSPENSIONE
PENDINI E COLLARI – ASSIEME

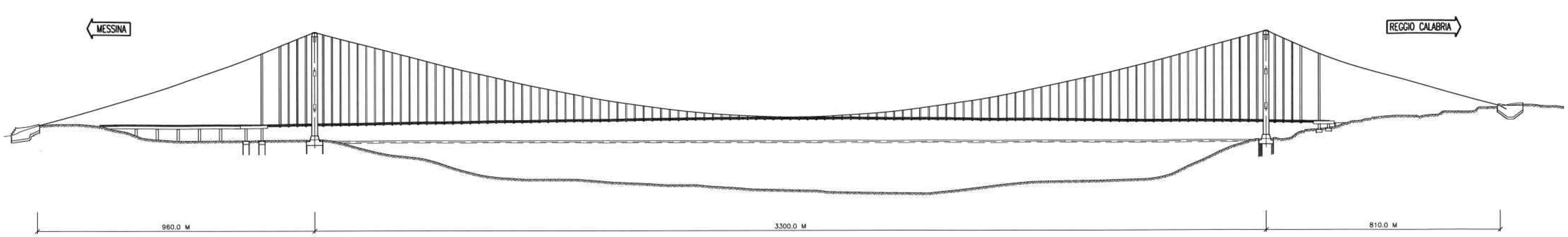
CODICE C G 1 0 0 0 P A X D P C G S 5 P E 0 0 0 0 0 0 0 1 A SCALA VARIE

REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	26-07-2010	EMISSIONE	KMR/CMRX	BTX	EMVX/LSJ

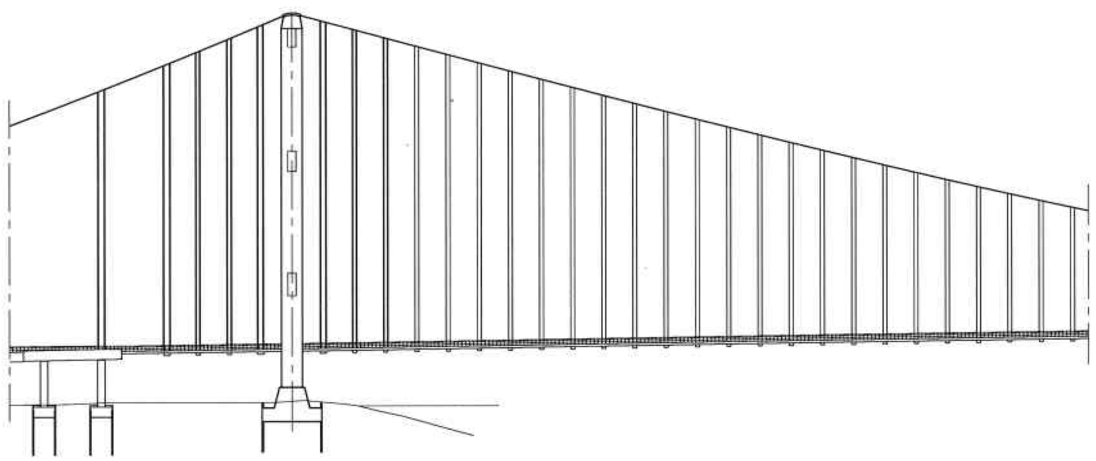
NOME DEL FILE: CG1000-PAXDPCG-S5PE000000-01

Appendix 4.2.H - Reference drawing, Steel Box Girders

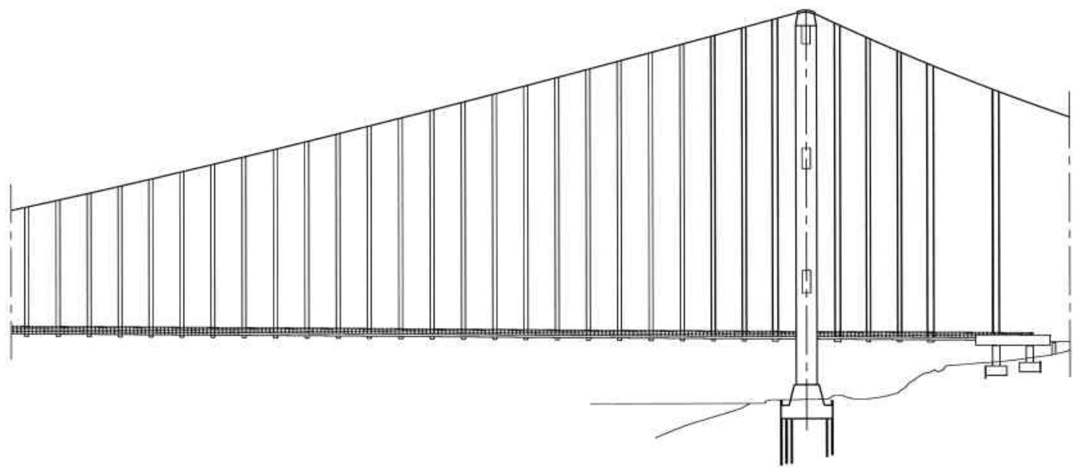
ELEVATION
SCALA 1:5000



ELEVATION
SCALA 1:2500



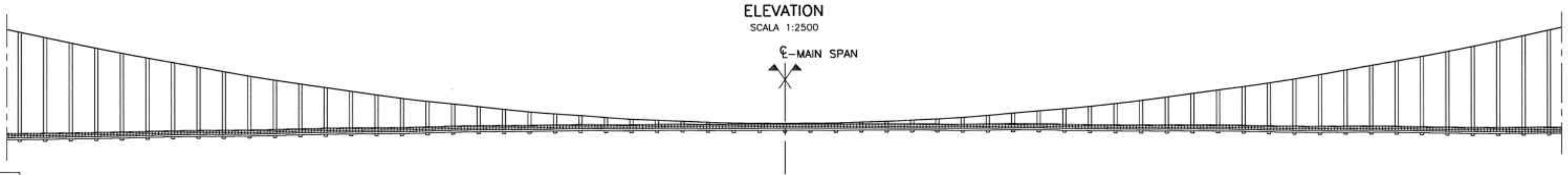
ELEVATION
SCALA 1:2500



SUSPENDED DECK																															
SECTION NO.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
LENGTH (M)	14.16	24.63	47.75	30.0	30.0	30.0	60.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
CROSS GIRDER TYPE	T7	T6	T1	T3	T4a	T4b	T3	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	
ROADWAY GIRDER TYPE	CS7	CS6	CS2	CS5	CS4	CS5	CS8	CS3	CS2																						
RAILWAY GIRDER TYPE	CF9	CF8	CF7	CF6	CF5	CF3	CF4	CF3	CF5	CF2	CF1																				

SECTION NO.	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
LENGTH (M)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	60.0	30.0	30.0	30.0	47.75	24.63	14.16
CROSS GIRDER TYPE	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T3	T4b	T4a	T3	T1	T6	T7	
ROADWAY GIRDER TYPE	CS2	CS3	CS8	CS5	CS4	CS5	CS2	CS6	CS7																						
RAILWAY GIRDER TYPE	CF1	CF2	CF5	CF3	CF4	CF3	CF5	CF6	CF7	CF8	CF9																				

ELEVATION
SCALA 1:2500



SUSPENDED DECK																																																													
SECTION NO.	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
LENGTH (M)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	
CROSS GIRDER TYPE	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1	T1
ROADWAY GIRDER TYPE	CS2	CS1	CS2																																																											
RAILWAY GIRDER TYPE	CF1																																																													

NOTES:

DIMENSIONS: DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.

REFERENCES:

PG 2D B0-005_1 N01 1 GENERAL NOTES

Stretto di Messina

STRETTO DI MESSINA S.p.A – CONCESSIONARIA DI STATO D.I.M. n. 3437/85
LEGGE n. 1158/71 PER UN COLLEGAMENTO STABILE VIARIO E FERROVIARIO TRA LA SICILIA E IL CONTINENTE

PONTE SULLO STRETTO DI MESSINA

PROGETTO DI GARA

ASSOCIAZIONE TEMPORANEA DI IMPRESE
IMPREGILO S.p.A. (MANDATARIA)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (MANDANTE)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. DI RAVENNA SOC. COOP. A.R.L. (MANDANTE)
SACYR S.A.U. (MANDANTE)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. LTD. (MANDANTE)
A.C.I. S.C.P.A. - CONSORZIO STABILE (MANDANTE)

PROGETTISTI

COWI A/S
BUCKLAND & TAYLOR LTD
SUND & BÆLT PARTNER LTD

BATIMAT SRL
IN.CO INGEGNERI CONSULENTI S.P.A.
MCA - ADVANCED ENGINEERING SRL
SINA S.P.A.
SINT INGEGNERIA SRL
STUDIO PROFESSIONALE ASSOCIATO INGG. FERRO E CERIONI
PROF.SSA LA TORRE BELLARDONI
UFFICI TECNICI A.T.I.

CONSULENZE E RICERCHE

PARTE: 2 - IL PONTE ED I SUOI COLLEGAMENTI -

L'OPERA D'ATTRAVERSAMENTO
SUSPENDED DECK
OVERVIEW

ELAB.	PROGETTO	PARTE	CODICE	n°	Rev.	Scala:	Data:
	PG	2 D	B0-009_ V01	1	0	VARIE	20/04/05

Società:	Redatto:	Controllato:	Approvato:
COWI	HPO/INB	TOF	HPO/HHJC

05-04-2005 Nome File: PG_2D_B0-009_V01_1.dgn

Appendix 4.2.I - Reference drawing, diaphragms and cells in Roadway Girders

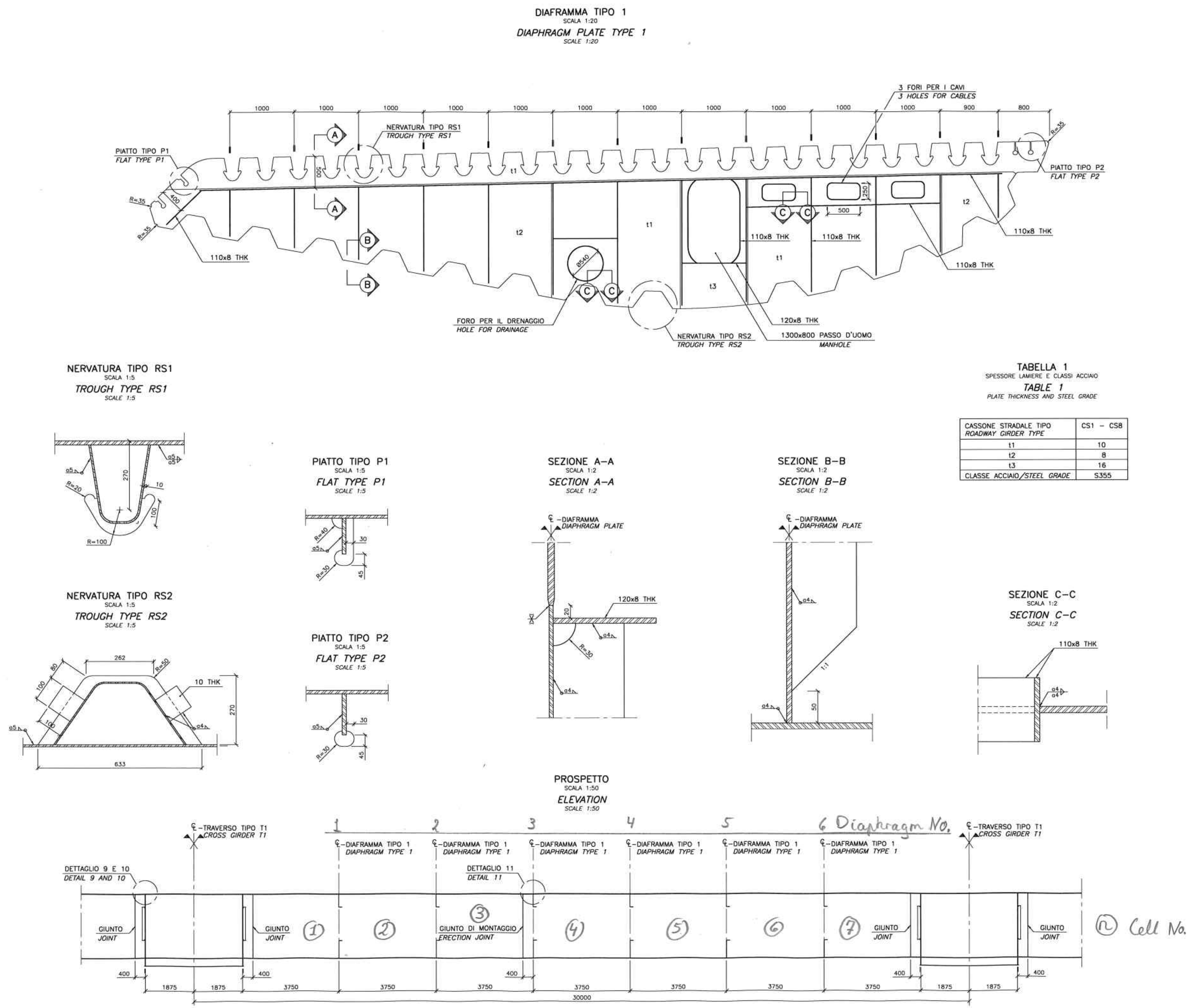


TABELLA 1
SPESSORE LAMIERE E CLASSI ACCIAIO
TABLE 1
PLATE THICKNESS AND STEEL GRADE

CASSONE STRADALE TIPO / *ROADWAY GIRDER TYPE*	CS1 – CS8
t1	10
t2	8
t3	16
CLASSE ACCIAIO/*STEEL GRADE*	S355

NOTE GENERALI

NOTE:
DIMENSIONI: TUTTE LE DIMENSIONI SONO IN MILLIMETRI, SALVO OVE DIVERSAMENTE INDICATO.
MATERIALI: CLASSE ACCIAIO SECONDO TABELLA 1.

LEGENDA:
ACCIAIO

ELABORATI DI RIFERIMENTO:
CG1000– NOTE GENERALI

NOTES:
DIMENSIONS: DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED.
MATERIALS: STEEL GRADE ACCORDING TO TABLE 1.

LEGENDS:
STEEL

REFERENCES:
CG1000– GENERAL NOTES

QUESTO ELABORATO GRAFICO VA LETTO INSIEME A:
THIS DRAWING TO BE READ IN CONJUNCTION WITH:
CG1000–PWXDPCG–S5CS000000–01
CG1000–PAXDPCG–S5CS000000–01
CG1000–PAXDPCG–S5CS000000–02

Stretto di Messina

EurolinK

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

IL PROGETTISTA / PROJECT MANAGER	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE	IL CONTRAENTE GENERALE / PROJECT MANAGER	STRETTO DI MESSINA
(Ing. E.M. Veje) COWI	(Dott. Ing..........)	(Ing. P.P. Marcheselli)	
DATA	DATA	DATA	DATA

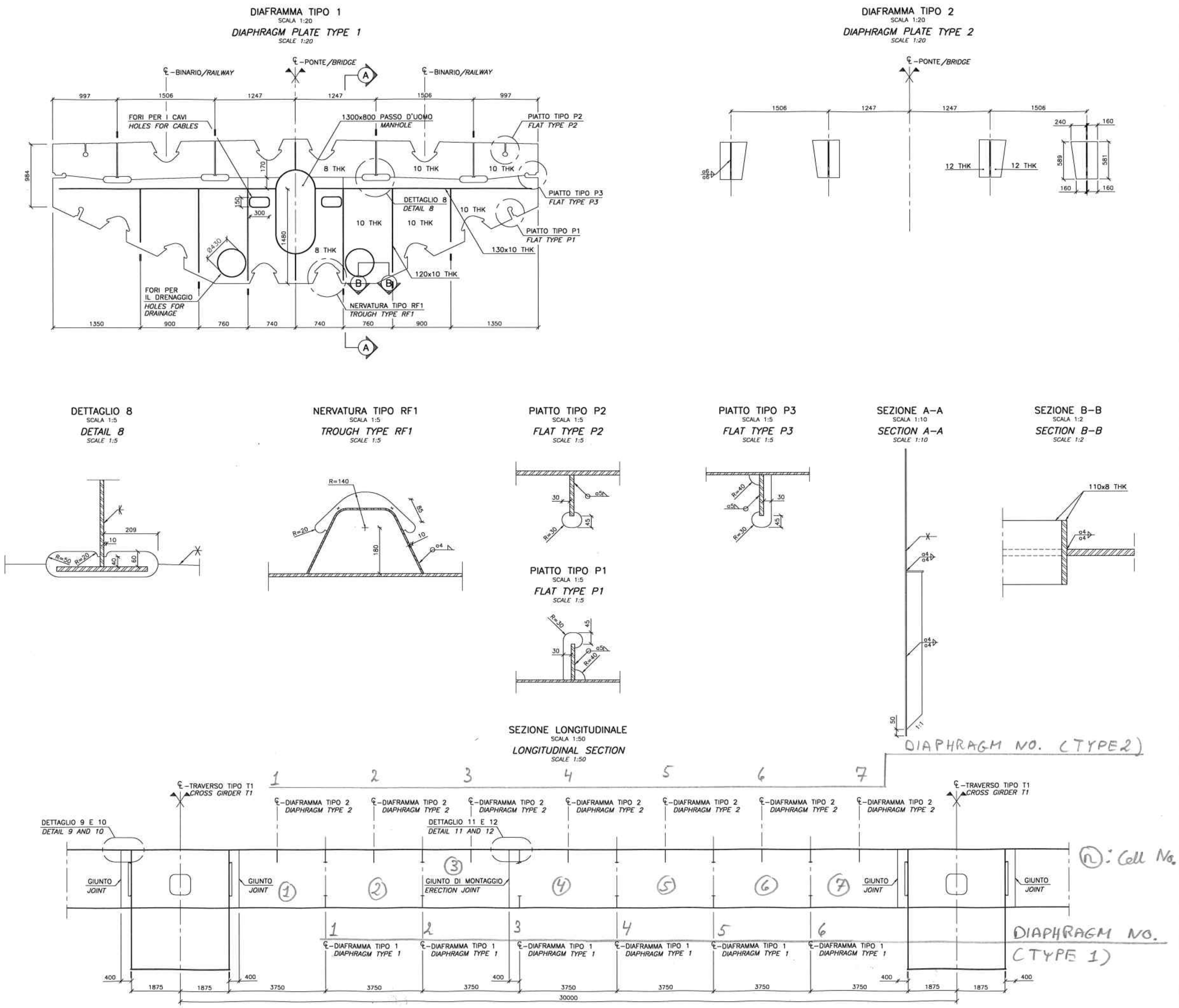
OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
IMPALCATO SOSPESO
IMPALCATO STRADALE–CAMPATA CENTRALE E LATERALI–DIAFRAMMI

CODICE: C G 1 0 0 0 P A X D P C G S 5 C S 0 0 D 0 0 0 0 1 A — SCALA: VARIE

REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	26-07-2010	EMISSIONE	LHJ/HEAE	HPO	HPO/LSJ

NOME DEL FILE: CG1000-PAXDPCG-S5CS000000-01.DWG — revisione interna

Appendix 4.2.J - Reference drawing, diaphragms and cells in Railway Girder



NOTE GENERALI

NOTE:

DIMENSIONI: TUTTE LE DIMENSIONI SONO IN MILLIMETRI, SALVO OVE DIVERSAMENTE INDICATO.

MATERIALI: CLASSE ACCIAIO SECONDO TABELLA 1.

LEGENDA:

ACCIAIO

ELABORATI DI RIFERIMENTO:

CG1000– NOTE GENERALI

NOTES:

DIMENSIONS: DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED.

MATERIALS: STEEL GRADE ACCORDING TO TABLE 1.

LEGENDS:

STEEL

REFERENCES:

CG1000– GENERAL NOTES

QUESTO ELABORATO GRAFICO VA LETTO INSIEME A:
THIS DRAWING TO BE READ IN CONJUNCTION WITH:
CG1000–PWXDPCG–S5CF000000–01
CG1000–PAXDPCG–S5CF000000–01
CG1000–PAXDPCG–S5CF000000–02

Stretto di Messina

Eurolink

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a.r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

IL PROGETTISTA PROJECT MANAGER (Ing. E.M. Veje) COWI	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE (Dott. Ing. ......)	IL CONTRAENTE GENERALE PROJECT MANAGER (Ing. P.P. Marcheselli)	STRETTO DI MESSINA
DATA	DATA	DATA	DATA

OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
IMPALCATO SOSPESO
IMPALCATO FERROVIARIO–CAMPATA CENTRALE–DIAFRAMMI

CODICE: C G 1 0 0 0 P A X D P C G S 5 C F 0 0 0 0 0 0 0 1 A — SCALA: VARIE

REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	26-07-2010	EMISSIONE	LHJ/AMOL	HPO	HPO/LSJ

NOME DEL FILE: CG1000-PAXDPCG-S5CF000000-01.DWG — revisione interna

Appendix 4.2.K - Reference drawing, diaphragms and cells in Cross Girders

SEZIONE A–A
SCALA 1:50
SECTION A–A
SCALE 1:50

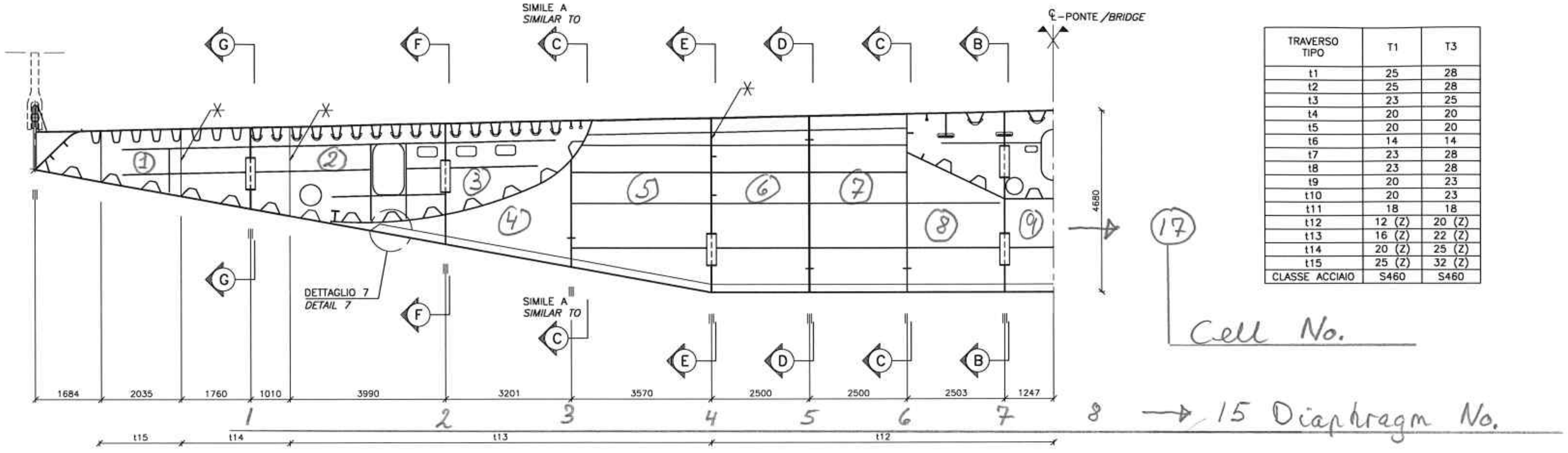
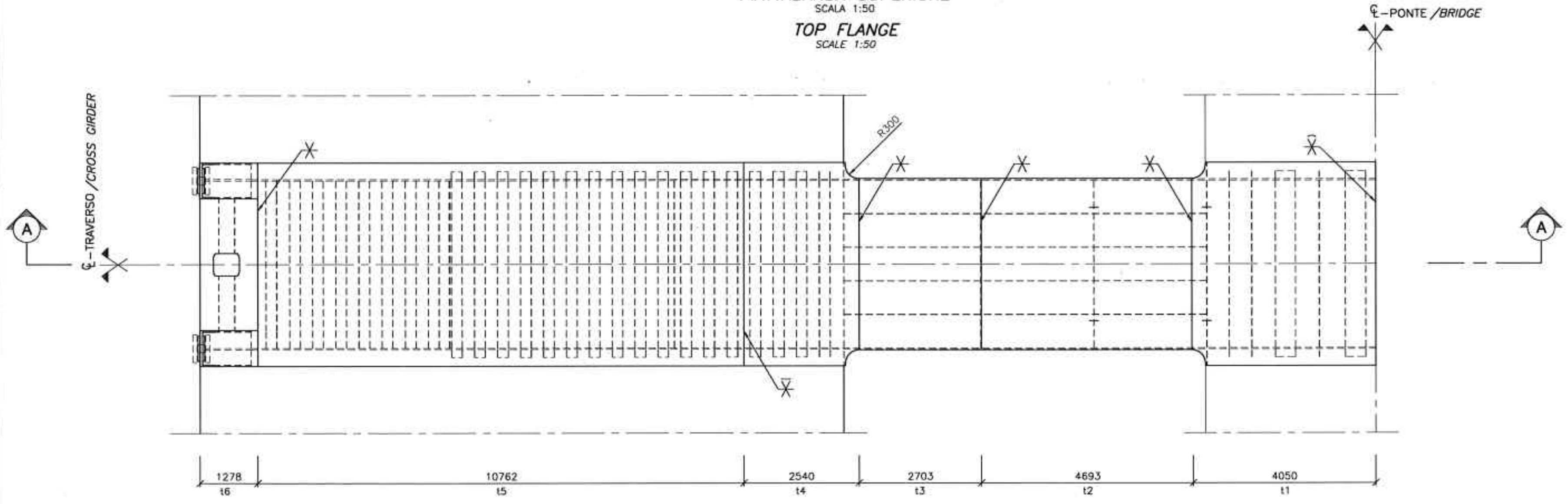


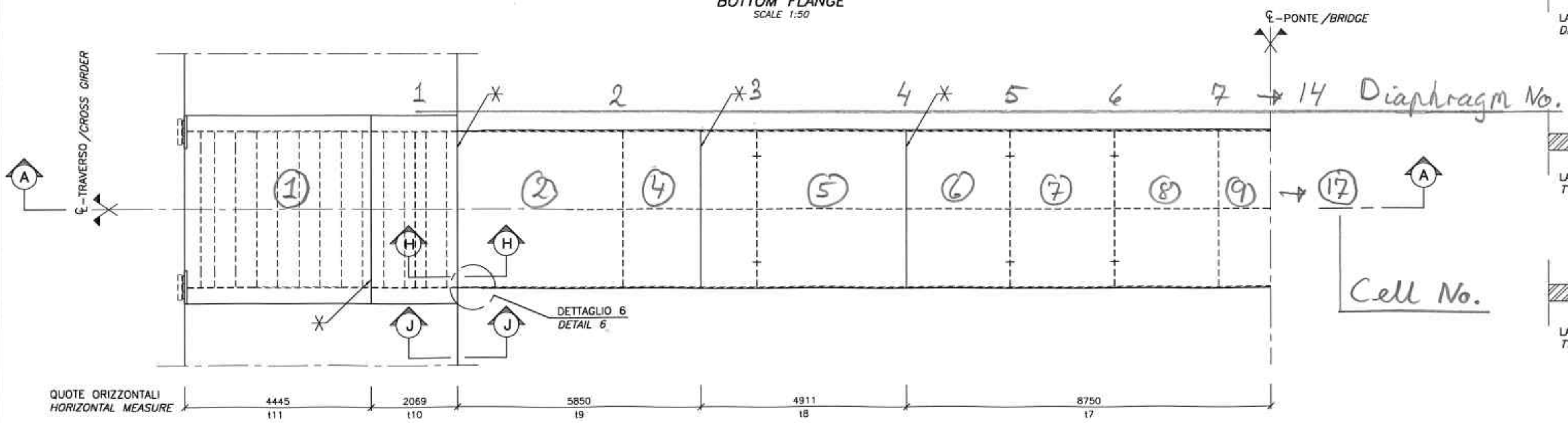
TABELLA 1
SPESSORE LAMIERE E CLASSE ACCIAIO
TABLE 1
PLATE THICKNESS AND STEEL GRADE

TRAVERSO TIPO	T1	T3
t1	25	28
t2	25	28
t3	23	25
t4	20	20
t5	20	20
t6	14	14
t7	23	28
t8	23	28
t9	20	23
t10	20	23
t11	18	18
t12	12 (Z)	20 (Z)
t13	16 (Z)	22 (Z)
t14	20 (Z)	25 (Z)
t15	25 (Z)	32 (Z)
CLASSE ACCIAIO	S460	S460

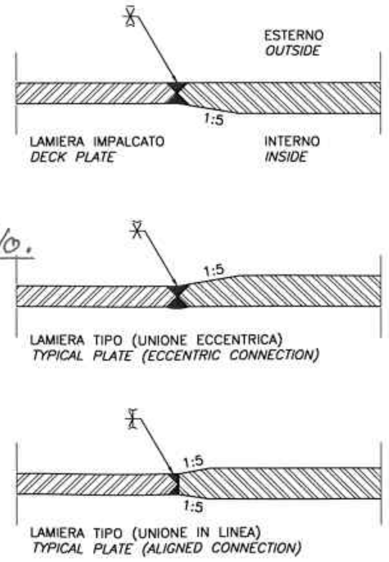
PIATTABANDA SUPERIORE
SCALA 1:50
TOP FLANGE
SCALE 1:50



PIATTABANDA INFERIORE
SCALA 1:50
BOTTOM FLANGE
SCALE 1:50



SALDATURE TIPO TRA LAMIERE DI SPESSORI DIVERSI
TYPICAL WELDING BETWEEN PLATES OF DIFFERENT THICKNESS



NOTE GENERALI

NOTE:

DIMENSIONI: TUTTE LE DIMENSIONI SONO IN MILLIMETRI, SALVO OVE DIVERSAMENTE INDICATO. GLI ANGOLI SONO IN GRADI (0°–360°).

MATERIALI: CLASSE ACCIAIO SECONDO TABELLA 1.

ELABORATI DI RIFERIMENTO:

PD– NOTE GENERALI

NOTES:

DIMENSIONS: DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED. ANGLES ARE IN DEGREES (0°–360°).

MATERIALS: STEEL GRADE ACCORDING TO TABLE 1.

REFERENCES:

PD– GENERAL NOTES

QUESTO ELABORATO GRAFICO VA LETTO INSIEME A:
THIS DRAWING TO BE READ IN CONJUNCTION WITH:
CG1000–PAXDPCG–S5TP000000–01
CG1000–PAXDPCG–S5TP000000–01
CG1000–PAXDPCG–S5TP000000–02

Stretto di Messina

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

IL PROGETTISTA / PROJECT MANAGER	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE	IL CONTRAENTE GENERALE / PROJECT MANAGER	STRETTO DI MESSINA
(Ing. E.M. Veje) COWI	(Dott. Ing. ....)	(Ing. P.P. Marcheselli)	
DATA	DATA	DATA	DATA

OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
IMPALCATO SOSPESO
TRAVERSI – CAMPATA CENTRALE – SEZIONE 1

CODICE: CG1000PWXDPCGS5TP0000000 1 A — SCALA: 1:50

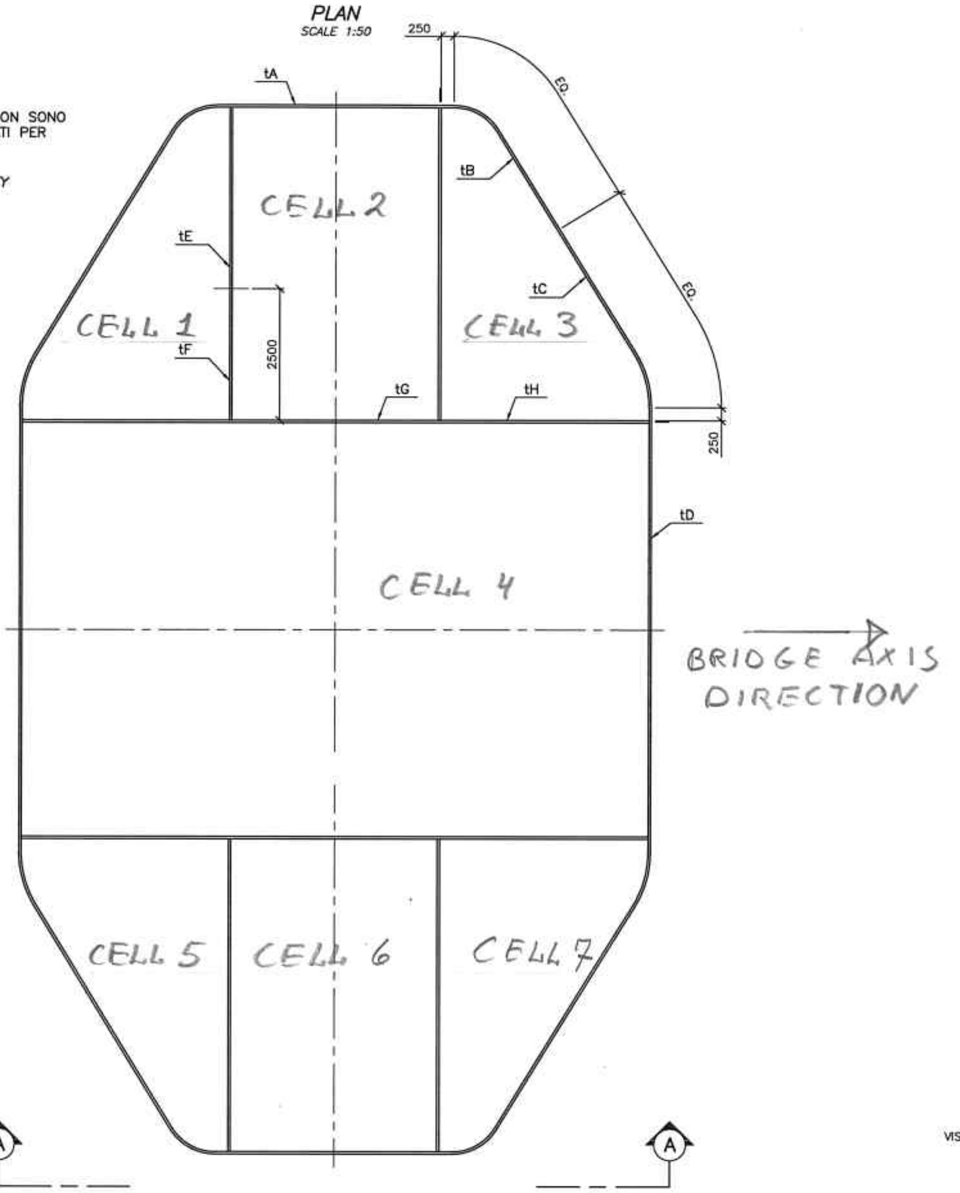
REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	20-07-2010	EMISSIONE	TM/HEAE	HPD	HPD/LSJ

NOME DEL FILE: CG1000-PAXDPCG-S5TP000000-01.DWG — revisione interna

Appendix 4.2.L - Reference drawing, Towers

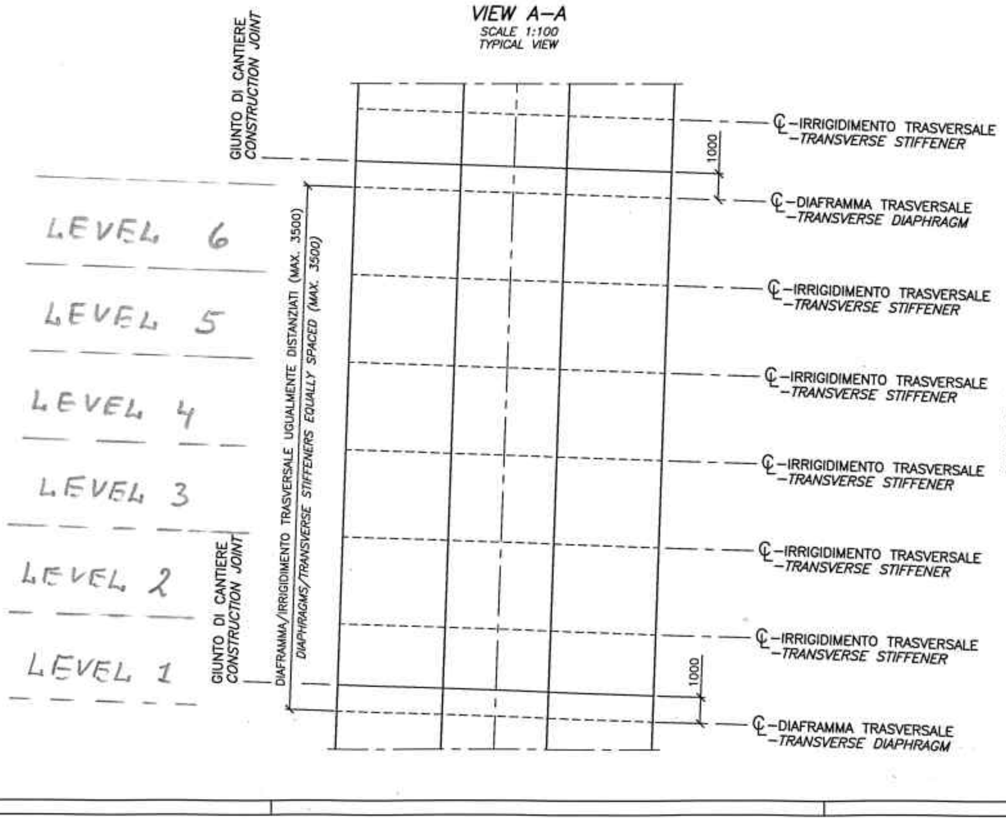
PIANTA
SCALA 1:50
PLAN
SCALE 1:50

GLI IRRIGIDIMENTI NON SONO STATI RAPPRESENTATI PER CHIAREZZA
STIFFENERS NOT SHOWN FOR CLARITY

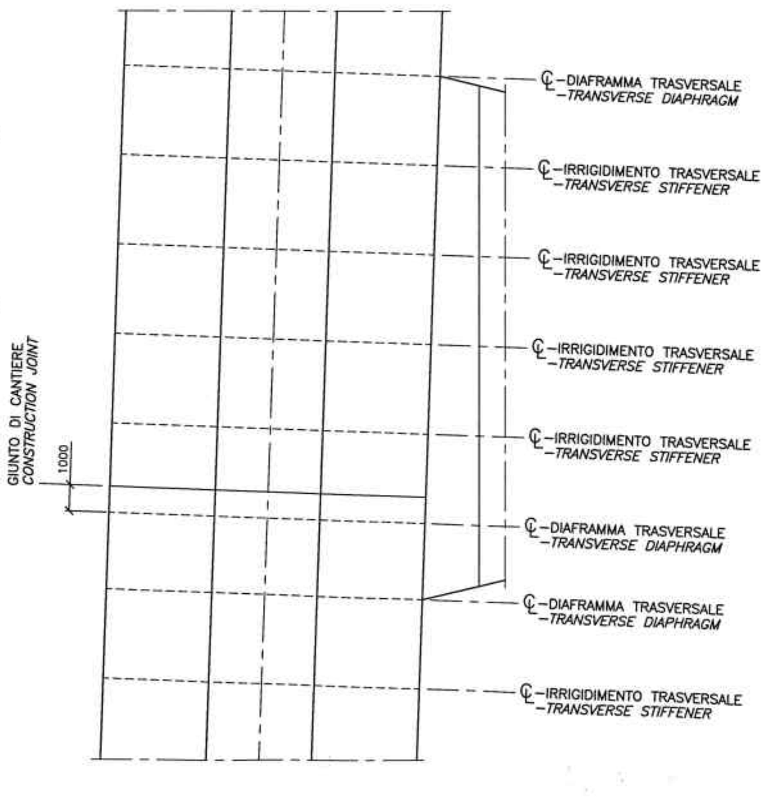


CONCIO *SEGMENT*	SPESSORE LAMIERA / *PLATE THICKNESS*								N. DI DIARAMMMI TRASVERSALI / *No. OF TRANSVERSE DIAPHRAGMS*	N. DI IRRIGIDIMENTI TRASVERSALI / *No. OF TRANSVERSE STIFFENERS*
	tA	tB	tC	tD	tE	tF	tG	tH		
1	90	90	90	85	85	80	75	75	1	2
2	80	80	80	75	80	70	65	65	1	3
3	80	80	70	60	65	55	45	45	1	4
4	80	80	55	45	55	45	45	45	1	4
5	75	75	50	35	50	35	35	35	1	4
6	65	60	45	45	45	35	35	35	1	5
7	65	65	60	65	50	40	35	35	2	4
8	70	70	70	70	60	60	45	45	2	5
9	60	60	60	55	50	45	45	45	1	5
10	60	60	50	45	50	35	35	35	1	5
11	55	55	40	40	40	35	35	35	1	5
12	55	55	50	50	45	35	35	35	1	5
13	60	60	60	60	50	40	35	35	2	4
14	70	70	55	50	50	35	35	35	2	4
15	75	70	60	55	55	35	35	35	1	5
16	75	75	55	55	55	35	35	35	1	5
17	70	70	50	50	60	35	35	35	1	5
18	65	60	55	55	45	35	35	35	1	5
19	50	50	50	55	35	40	35	35	1	4
20	40	40	45	45	35	45	35	35	2	2
21	45	35	45	45	45	40	40	45	1	4

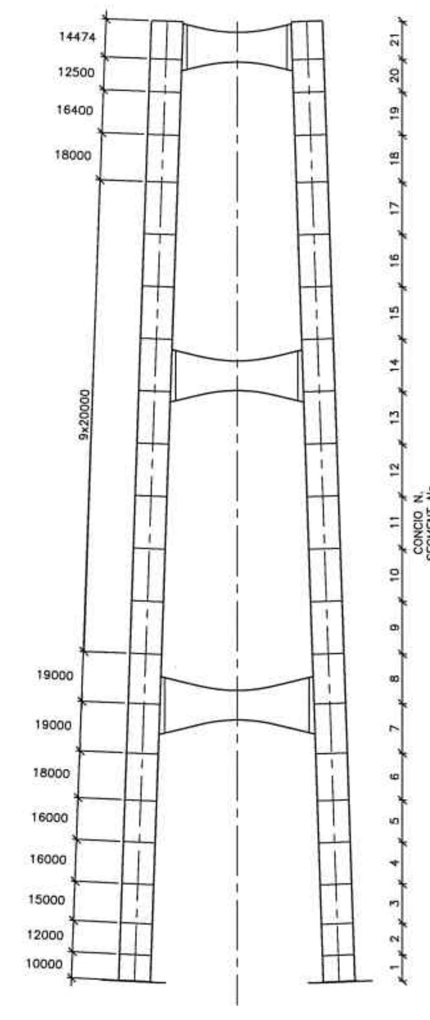
VISTA A–A
SCALA 1:100
VISTA TIPICO
VIEW A–A
SCALE 1:100
TYPICAL VIEW



VISTA A–A
SCALA 1:100
VISTA IN CORRISPONDENZA DEL TRASVERSO 2
VIEW A–A
SCALE 1:100
VIEW AT CROSS BEAM 2



PROSPETTO TRASVERSALE
SCALA 1:1000
TRANSVERSE ELEVATION
SCALE 1:1000



NOTE GENERALI

NOTE:

DIMENSIONI: TUTTE LE DIMENSIONI SONO IN MILLIMETRI, SALVO OVE DIVERSAMENTE INDICATO.

MATERIALI: ACCIAIO STRUTTURALE S460ML (UNI EN 10025–4). L'ACCIAIO DEVE AVERE RESISTENZA ALLO SNERVAMENTO GARANTITA DI 460 MPa PER S460ML. PER TUTTI GLI SPESSORI DELLE LAMIERE FINO A 100MM. DOVE INDICATO SI DEVE UTILIZZARE ACCIAIO STRUTTURALE DI TIPO Z CON CERTIFICATE CARATTERISTICHE DI DEFORMAZIONE IN DIREZIONE TRASVERSALE CONFORME ALLA CLASSE Z25 (UNI EN 10164).

MOMENTO FLETTENTE IMPRESSO: SI INTRODUCE UN TIE–BACK PERMANENTE, APPLICATO IN TESTA ALLA TORRE MEDANTE IL CAVO PRINCIPALE, TALE DA DETERMINARE UNA FORZA DI TAGLIO PARI A 6.3 MN PER CIASCUNA GAMBA DELLA TORRE ED UNA CORRISPONDENTE DISTRIBUZIONE DEL MOMENTO FLETTENTE PERMANENTE NELLA TORRE.

NOTES:

DIMENSIONS: DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED.

MATERIALS: STRUCTURAL STEEL S460ML (EN 10025–4). STEEL MUST PROVIDE A GUARANTEED YIELD STRENGTH OF 460 MPa FOR ALL PLATE THICKNESSES UP TO 100 mm. WHERE INDICATED, TYPE Z STRUCTURAL STEEL WITH DEFORMATION PROPERTIES IN THE TRANSVERSE DIRECTION CERTIFIED TO EN 10164–Z25.

IMPOSED BENDING MOMENT: A PERMANENT TIE–BACK MUST BE INTRODUCED BY THE MAIN CABLE AT THE TOWER TOP SO AS TO PRODUCE A SHEAR FORCE OF 6.3 MN PER TOWER LEG, AND A CORRESPONDING DISTRIBUTION OF BENDING MOMENT.

Stretto di Messina

Eurolink

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.

IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

IL PROGETTISTA PROJECT MANAGER (Ing. E.M. Veje) COWI	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE (Dott. Ing..............)	IL CONTRAENTE GENERALE PROJECT MANAGER (Ing. P.P. Marcheselli)	STRETTO DI MESSINA
DATA	DATA	DATA	DATA

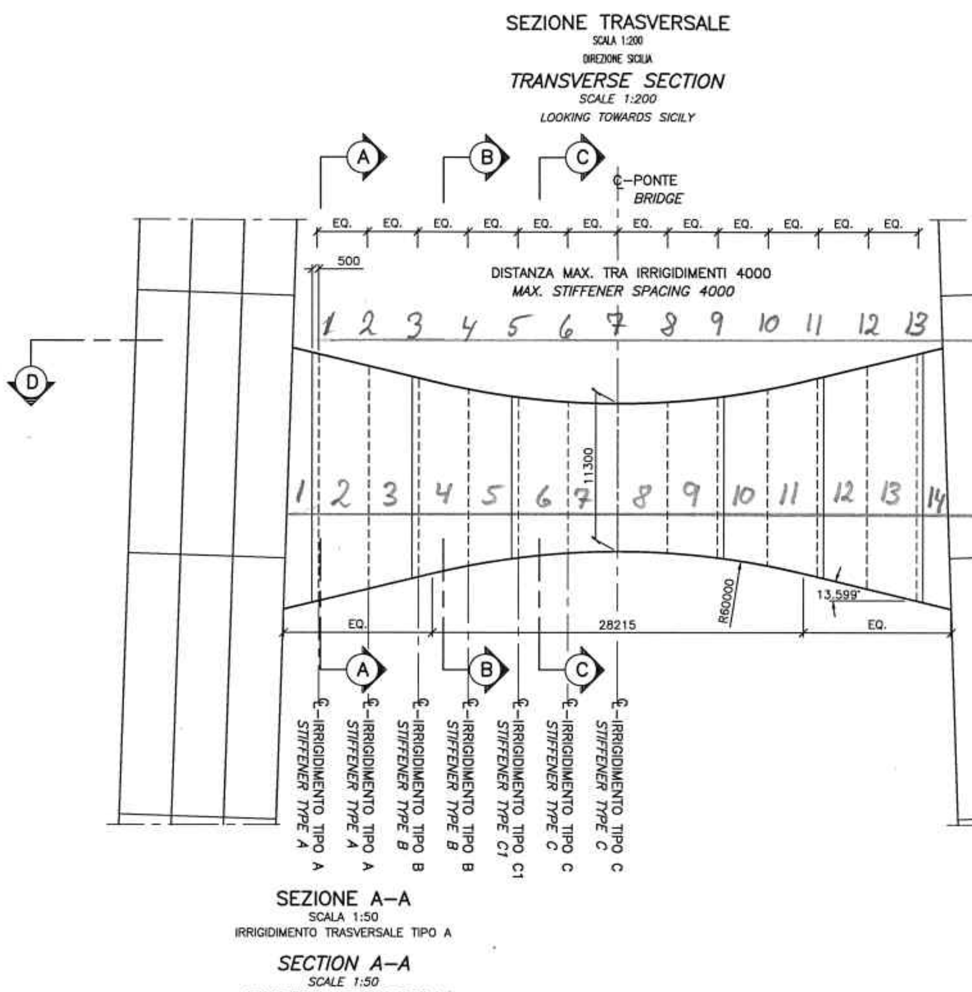
OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
TORRI
TORRE SICILIA – TIPOLOGICO GAMBA – SEZIONI SPESSORI LAMIERE

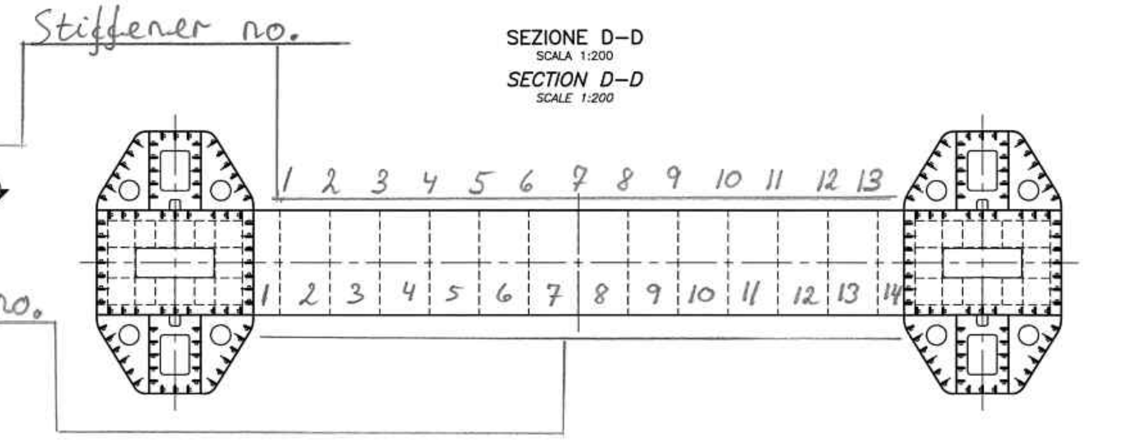
CODICE C G 1 0 0 0 P W X D P C G S 5 T S 0 0 0 0 0 0 0 1 A — SCALA: VARIE

REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	26-07-2010	EMISSIONE	CTL/MJK	CHSX	EMSX/LSJ

NOME DEL FILE: CG1000–PWXDPCG–S5TS0000000–01.DWG — revisione interna: — COWI No.

Appendix 4.2.M - Reference drawing, Cross Beams





NOTE GENERALI

NOTE:

DIMENSIONI: TUTTE LE DIMENSIONI SONO IN MILLIMETRI, SALVO OVE DIVERSAMENTE INDICATO. GLI ANGOLI SONO IN GRADI (0°–360°).

MATERIALI: ACCIAIO STRUTTURALE S460ML (UNI EN 10025–4). L'ACCIAIO DEVE AVERE RESISTENZA ALLO SNERVAMENTO GARANTITA DI 460 MPa PER S460ML, PER TUTTI GLI SPESSORI DELLE LAMIERE FINO A 100MM. DOVE INDICATO SI DEVE UTILIZZARE ACCIAIO STRUTTURALE DI TIPO Z CON CERTIFICATE CARATTERISTICHE DI DEFORMAZIONE IN DIREZIONE TRASVERSALE CONFORME ALLA CLASSE Z25 (UNI EN 10164).

NOTES:

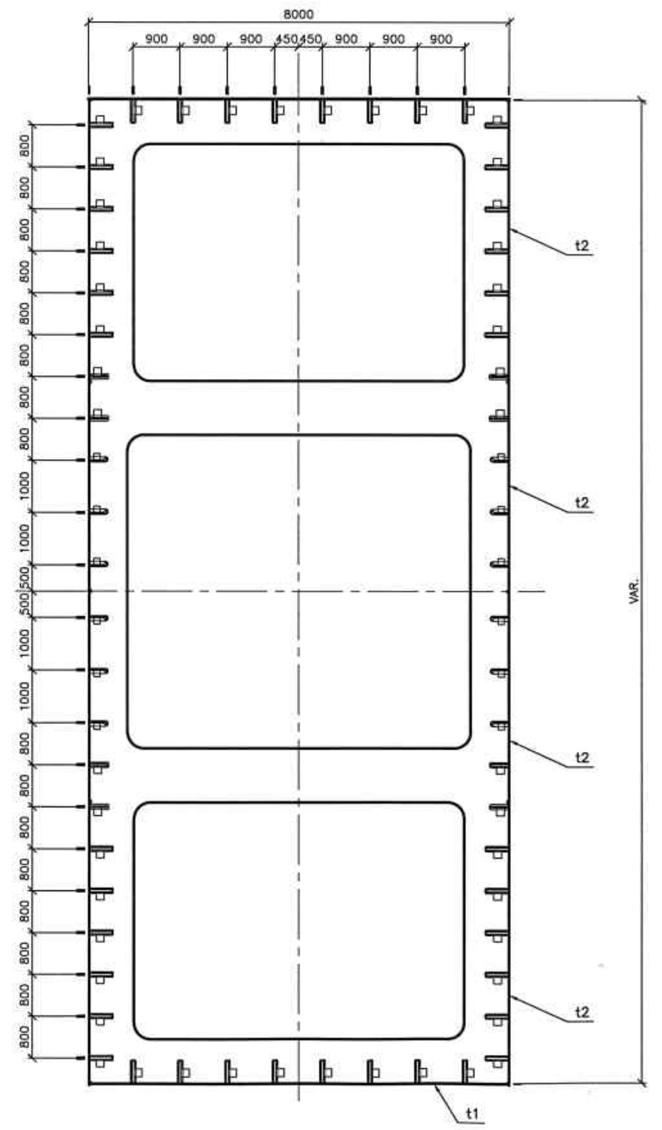
DIMENSIONS: DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED. ANGLES ARE IN DEGREES (0°–360°).

MATERIALS: STRUCTURAL STEEL S460ML (EN 10025–4). STEEL MUST PROVIDE A GUARANTEED YIELD STRENGTH OF 460 MPa FOR ALL PLATE THICKNESSES UP TO 100 mm. WHERE INDICATED, TYPE Z STRUCTURAL STEEL WITH DEFORMATION PROPERTIES IN THE TRANSVERSE DIRECTION CERTIFIED TO EN 10164–Z25.

	SPESSORE LAMIERA / *PLATE THICKNESS*					
	t1 MM	t2 MM	t3 MM	t4 MM	t5 MM	t6 MM
TRASVERSO N. 1 / *CROSS BEAM No. 1*	25	20	25	25	25	30
TRASVERSO N. 2 / *CROSS BEAM No. 2*	30	25	30	30	30	35
TRASVERSO N. 3 / *CROSS BEAM No. 3*	25	25	30	25	25	30

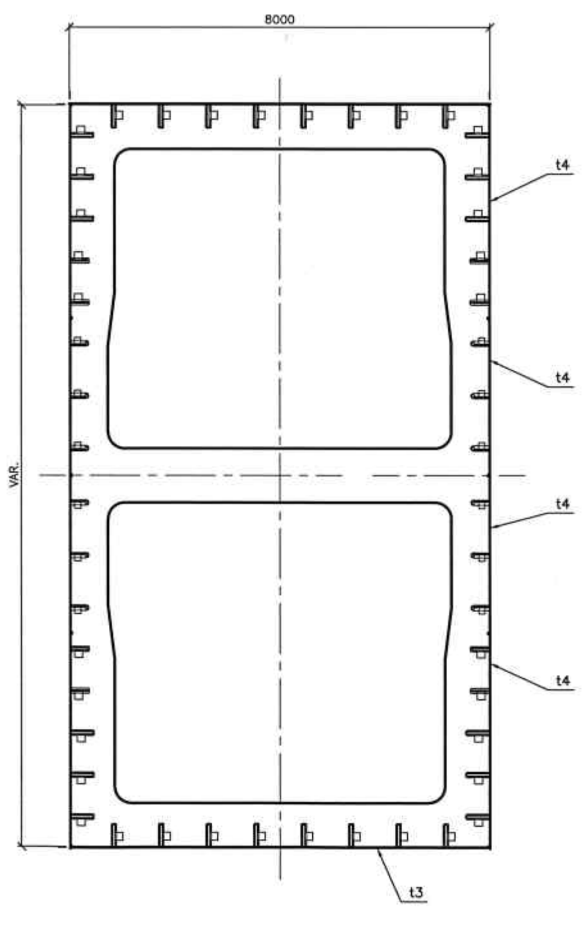
SEZIONE A–A
SCALA 1:50
IRRIGIDIMENTO TRASVERSALE TIPO A

SECTION A–A
SCALE 1:50
TRANSVERSE STIFFENER TYPE A



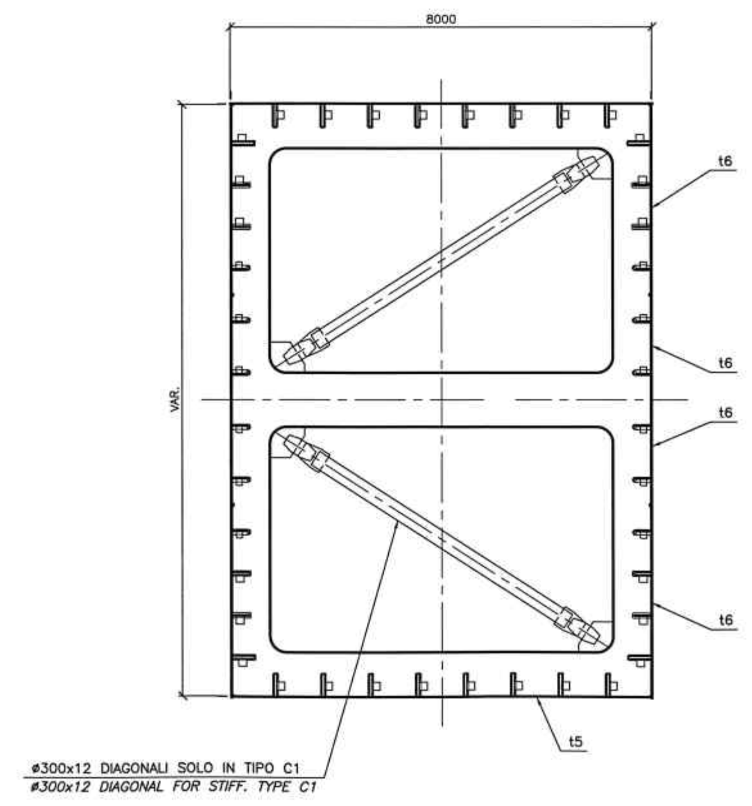
SEZIONE B–B
SCALA 1:50
IRRIGIDIMENTO TRASVERSALE TIPO B

SECTION B–B
SCALE 1:50
TRANSVERSE STIFFENER TYPE B



SEZIONE C–C
SCALA 1:50
IRRIGIDIMENTO TRASVERSALE TIPO C E C1

SECTION C–C
SCALE 1:50
TRANSVERSE STIFFENER TYPES C & C1



ø300x12 DIAGONALI SOLO IN TIPO C1
ø300x12 DIAGONAL FOR STIFF. TYPE C1

Stretto di Messina

Eurolink

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a.r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
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IL PROGETTISTA PROJECT MANAGER (Ing. E.M. Veje) COWI	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE (Dott. Ing..........)	IL CONTRAENTE GENERALE PROJECT MANAGER (Ing. P.P. Marcheselli)	STRETTO DI MESSINA
DATA	DATA	DATA	DATA

OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
TORRI
TORRI – TIPOLOGICO – TRASVERSO No. 1

CODICE CG1000PAXDPCGS5T0T000001 A — SCALA: VARIE

REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	26/07–2010	EMISSIONE	CTL/JE/MJK	CMK	CHSX/LSJ

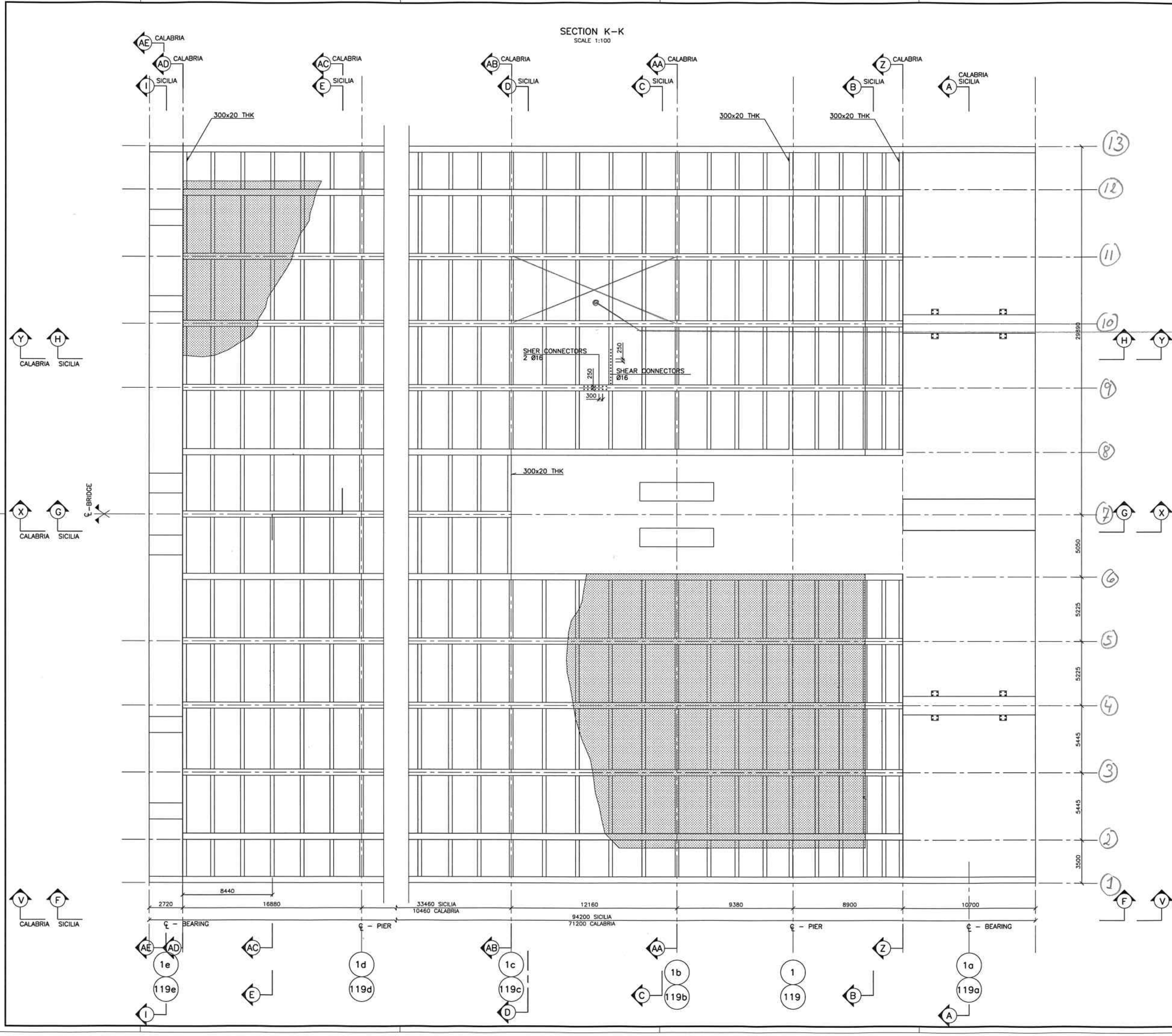
NOME DEL FILE: CG1000–PAXDPCG–S5T0T00000–01.DWG

revisione interna:

COWI No.

Appendix 4.2.N - Reference drawing, Terminal Structures

SECTION K–K
SCALE 1:100



NOTE GENERALI

NOTES:

DIMENSIONS: DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE NOTED.

LEGENDS:

CONCRETE C45/55

REFERENCES:

PG 2D B0-005_1 N01 1 GENERAL NOTES

1 - 13 : Beam No.

Field No. , for example

Field no.

(10 - 11) , (1b - 1c) ,

on the Sicily side

THIS DRAWING TO BE READ IN CONJUNCTION WITH
PG 2D B0-017_N11 1,
PG 2D B0-017_N13 1,
PG 2D B0-017_N14 1,
PG 2D B0-017_N15 1,
PG 2D B0-017_N16 1,
PG 2D B0-017_N17 1,
PG 2D B0-017_N18 1,
PG 2D B0-017_N19 1,
PG 2D B0-017_N20 1,
PG 2D B0-017_N21 1

Stretto di Messina

STRETTO DI MESSINA S.p.A – CONCESSIONARIA DI STATO D.I.M. n. 3437/85
LEGGE n. 1158/71 PER UN COLLEGAMENTO STABILE VIARIO E FERROVIARIO TRA LA SICILIA E IL CONTINENTE

PONTE SULLO STRETTO DI MESSINA

PROGETTO DI GARA

ASSOCIAZIONE TEMPORANEA DI IMPRESE
IMPREGILO S.p.A. (MANDATARIA)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.P.A. (MANDANTE)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. DI RAVENNA SOC. COOP. A.R.L. (MANDANTE)
SACYR S.A.U. (MANDANTE)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. LTD. (MANDANTE)
A.C.I. S.C.P.A. - CONSORZIO STABILE (MANDANTE)

PROGETTISTI

COWI A/S
BUCKLAND & TAYLOR LTD
SUND & BÆLT PARTNER LTD

BATIMAT SRL
IN.CO INGEGNERI CONSULENTI S.P.A.
MCA - ADVANCED ENGINEERING SRL
SIKA S.P.A.
SINT INGEGNERIA SRL
STUDIO PROFESSIONALE ASSOCIATO INGG. FERRO E CERIONI
PROF.ESA LA TORRE BELLARDINI
UFFICI TECNICI A.T.I.

CONSULENZE E RICERCHE
UNIVERSITÀ DEGLI STUDI DI CATANIA - PROF. LENTINI
UNIVERSITÀ DEGLI STUDI DI REGGIO CALABRIA - PROF. ZARA
UNIVERSITÀ LA SAPIENZA - PROF. CINDESE

PARTE: 2 – IL PONTE ED I SUOI COLLEGAMENTI –

L'OPERA D'ATTRAVERSAMENTO
TERMINAL STRUCTURE SICILIA AND CALABRIA
SUPERSTRUCTURE - SECTIONS I

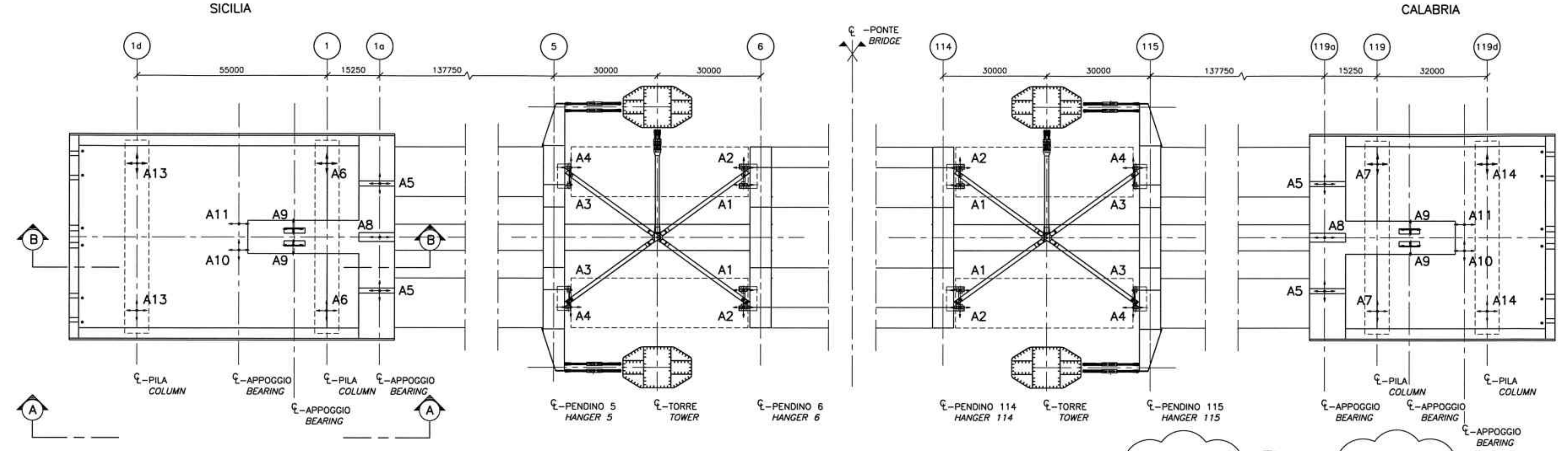
ELAB.	PROGETTO	PARTE	CODICE	n°	Rev.	Scala:	Data:
	PG	2 D	B 0 – 0 1 7 _ 1	N 1 2	1	0	1:100	20/04/05

Redatto:	Redatto:	Controllato:	Approvato:
COWI	JAMO/LL	LSJ	HPO/HHJC

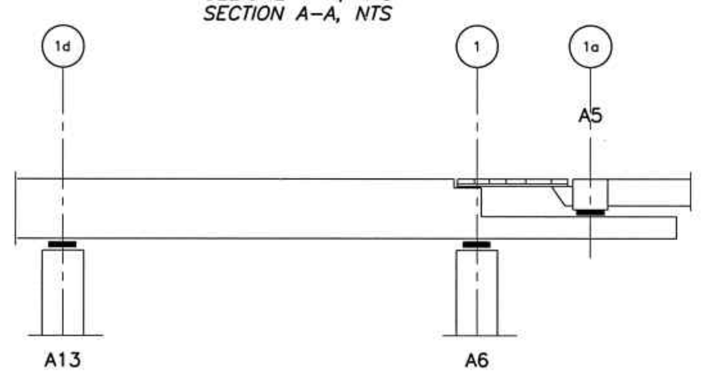
Prj: 15–04–2005 Nome File: PG_2D_B0–017_1_N12_1.dgn

Appendix 4.2.O - Reference drawing, Bearings

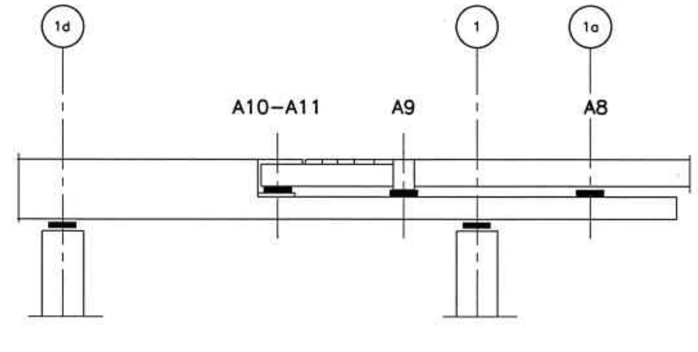
PIANTA
SCALA 1:500
PLAN
SCALE 1:500



SEZIONE A–A, NTS
SECTION A–A, NTS



SEZIONE B–B, NTS
SECTION B–B, NTS



HOLD

APPARECCHI D'APPOGGIO
BEARINGS

			CARICHI/ *LOAD* (MN)			SPOSTAMENTI/ *MOVEMENT* (m)			ROTAZIONI ATTORNO ALL'ASSE/ *ROTATIONS AROUND AXIS* (RAD)		
			SLS1	SLS2	ULS	SLS1	SLS2	ULS	SLS1	SLS2	ULS
A1(GS)	VETICALE/ *VERTICAL*	MAX.	1.2	1.7	2.7				0.010	0.015	0.020
		MIN.	0.7	0.4	−0.3				−0.010	−0.015	−0.020
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				0.400	0.550	0.700	0.010	0.020	0.025
		MIN.				−0.400	−0.550	−0.700	−0.010	−0.020	−0.025
	TRANSVERSALE/ *TRANSVERSE*	MAX.	0.6	1.0	2.0				0.015	0.025	0.035
		MIN.	−0.6	−1.0	−2.0				−0.015	−0.025	−0.035
A2(FS)	VETICALE/ *VERTICAL*	MAX.	1.2	1.7	2.7				0.010	0.015	0.020
		MIN.	0.7	0.4	−0.3				−0.010	−0.015	−0.020
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				0.400	0.550	0.700	0.010	0.020	0.025
		MIN.				−0.400	−0.550	−0.700	−0.010	−0.020	−0.025
	TRANSVERSALE/ *TRANSVERSE*	MAX.				0.020	0.020	0.020	0.015	0.025	0.035
		MIN.				−0.020	−0.020	−0.020	−0.015	−0.025	−0.035
A3(FX)	VETICALE/ *VERTICAL*	MAX.	1.6	2.7	3.7				0.010	0.015	0.020
		MIN.	0.4	−0.3	−0.8				−0.010	−0.015	−0.020
	LONGITUDINALE/ *LONGITUDINAL*	MAX.	0.7	1.5	3.0				0.010	0.010	0.010
		MIN.	−0.7	−1.5	−3.0				−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.	0.5	0.9	1.8				0.020	0.025	0.040
		MIN.	−0.5	−0.9	−1.8				−0.020	−0.025	−0.040
A4(FS)	VETICALE/ *VERTICAL*	MAX.	1.6	2.7	3.7				0.010	0.015	0.020
		MIN.	0.4	−0.3	−0.8				−0.010	−0.015	−0.020
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				0.050	0.070	0.100	0.010	0.010	0.010
		MIN.				−0.050	−0.070	−0.100	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.				0.020	0.020	0.020	0.020	0.025	0.040
		MIN.				−0.020	−0.020	−0.020	−0.020	−0.025	−0.040
A5(FS)	VETICALE/ *VERTICAL*	MAX.	14.0	18.0	25.0				0.020	0.030	0.040
		MIN.	1.0	−3.0	−8.0				−0.020	−0.030	−0.040
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				1.200	1.400	2.000	0.010	0.010	0.010
		MIN.				−1.200	−1.400	−2.000	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.				0.020	0.020	0.020	0.010	0.015	0.025
		MIN.				−0.020	−0.020	−0.020	−0.010	−0.015	−0.025
A6(FS)	VETICALE/ *VERTICAL*	MAX.	37.0	45.0	63.0				0.010	0.015	0.020
		MIN.	14.0	6.0	−7.5				−0.010	−0.015	−0.020
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				0.100	0.300	0.600	0.010	0.010	0.010
		MIN.				−0.100	−0.300	−0.600	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.				0.100	0.300	0.600	0.010	0.010	0.015
		MIN.				−0.100	−0.300	−0.600	−0.010	−0.010	−0.015
A7(FS)	VETICALE/ *VERTICAL*	MAX.	31.0	36.0	45.0				0.020	0.030	0.040
		MIN.	12.0	5.0	−3.5				−0.020	−0.030	−0.040
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				0.100	0.300	0.600	0.010	0.010	0.010
		MIN.				−0.100	−0.300	−0.600	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.				0.100	0.300	0.600	0.010	0.010	0.015
		MIN.				−0.100	−0.300	−0.600	−0.010	−0.010	−0.015
A8(HG)	VETICALE/ *VERTICAL*	MAX.							0.020	0.030	0.040
		MIN.							−0.020	−0.030	−0.040
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				1.200	1.400	2.000	0.010	0.010	0.010
		MIN.				−1.200	−1.400	−2.000	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.	3.0	6.0	12.0				0.010	0.015	0.025
		MIN.	−3.0	−6.0	−12.0				−0.010	−0.015	−0.025
A9(FS)	VETICALE/ *VERTICAL*	MAX.	7.5	10.0	13.0				0.020	0.030	0.040
		MIN.	0.8	−0.5	−2.8				−0.020	−0.030	−0.040
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				1.200	1.400	2.000	0.010	0.010	0.010
		MIN.				−1.200	−1.400	−2.000	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.				0.020	0.020	0.020	0.010	0.015	0.025
		MIN.				−0.020	−0.020	−0.020	−0.010	−0.015	−0.025
A10(FS)	VETICALE/ *VERTICAL*	MAX.	4.0	4.7	6.2				0.020	0.030	0.040
		MIN.	2.0	1.4	0.2				−0.020	−0.030	−0.040
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				1.200	1.400	2.000	0.010	0.010	0.010
		MIN.				−1.200	−1.400	−2.000	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.				0.020	0.020	0.020	0.010	0.010	0.010
		MIN.				−0.020	−0.020	−0.020	−0.010	−0.010	−0.010
A11(GS)	VETICALE/ *VERTICAL*	MAX.	4.0	4.7	6.2				0.020	0.030	0.040
		MIN.	2.0	1.4	0.2				−0.020	−0.030	−0.040
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				1.200	1.400	2.000	0.010	0.010	0.010
		MIN.				−1.200	−1.400	−2.000	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.	1.1	2.3	4.5				0.010	0.010	0.010
		MIN.	−1.1	−2.3	−4.5				−0.010	−0.010	−0.010
A13(FS)	VETICALE/ *VERTICAL*	MAX.	63.0	78.0	115.0				0.020	0.030	0.040
		MIN.	31.0	18.0	−11.1				−0.020	−0.030	−0.040
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				0.100	0.300	0.600	0.010	0.010	0.010
		MIN.				−0.100	−0.300	−0.600	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.				0.100	0.300	0.600	0.010	0.010	0.010
		MIN.				−0.100	−0.300	−0.600	−0.010	−0.010	−0.010
A14(FS)	VETICALE/ *VERTICAL*	MAX.	46.0	56.0	80.0				0.020	0.030	0.040
		MIN.	22.0	15.0	−1.0				−0.020	−0.030	−0.040
	LONGITUDINALE/ *LONGITUDINAL*	MAX.				0.100	0.300	0.600	0.010	0.010	0.010
		MIN.				−0.100	−0.300	−0.600	−0.010	−0.010	−0.010
	TRANSVERSALE/ *TRANSVERSE*	MAX.				0.100	0.300	0.600	0.010	0.010	0.010
		MIN.				−0.100	−0.300	−0.600	−0.010	−0.010	−0.010

NOTE GENERALI

NOTE:

DIMENSIONI: TUTTE LE DIMENSIONI SONO IN MILLIMETRI, SALVO OVE DIVERSAMENTE INDICATO.

LEGENDA:

FX: APPOGGIO FISSO.
FS: APPOGGIO MOBILE BIDIREZIONALE.
GS: APPOGGIO MOBILE UNIDIREZIONALE.
HG: GUIDA ORIZZONTALE.

SIMBOLI:

FX:
FS:
GS:
HG:

ELABORATI DI RIFERIMENTO:

NOTES:

DIMENSIONS: DIMENSIONS ARE IN MILLIMETRE UNLESS OTHERWISE NOTED.

LEGENDS:

FX: FIXED BEARING.
FS: FREE SLIDING – BI-DIRECTIONAL.
GS: GUIDED SLIDING – UNI-DIRECTIONAL.
HG: HORIZONTAL GUIDE.

SIGNATURE:

FX:
FS:
GS:
HG:

REFERENCES:

Stretto di Messina

Eurolink

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a.r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

IL PROGETTISTA PROJECT MANAGER (Ing. E.M. Veje) COWI	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE (Dott. Ing.______)	IL CONTRAENTE GENERALE PROJECT MANAGER (Ing. P.P. Marcheselli)	STRETTO DI MESSINA
DATA______	DATA______	DATA______	DATA______

OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
SISTEMA DI ARTICOLAZIONE
SCHEMA APPOGGI GENERALE

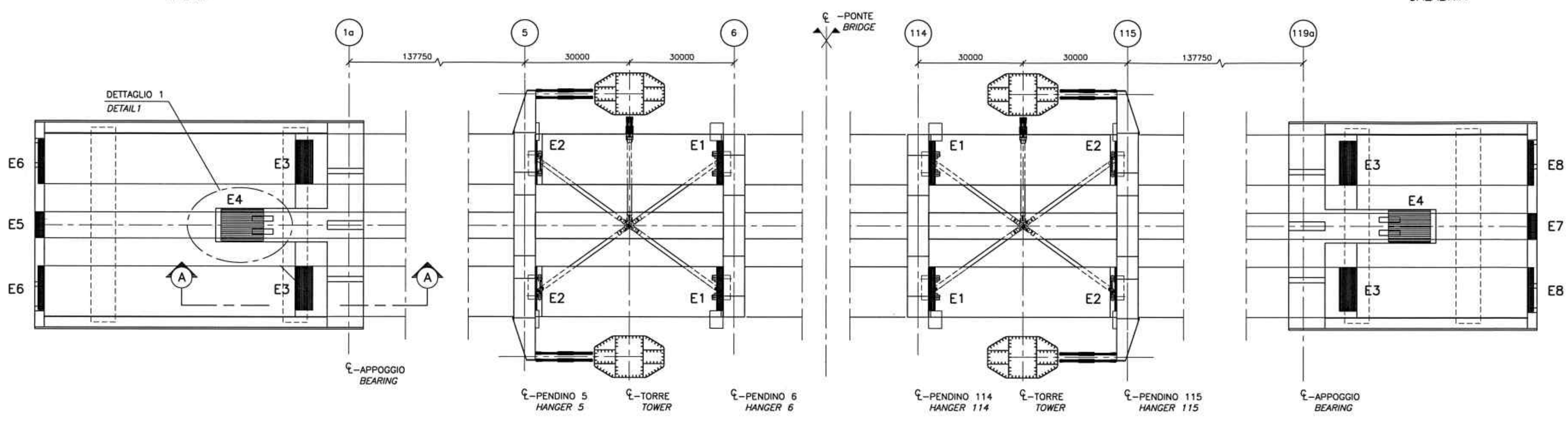
CODICE: C G 1 0 0 0 P A X D P C G S 5 A P 0 0 0 0 0 0 0 1 A — SCALA: VARIE

REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	26-07-2010	EMISSIONE	CHPP/HPJE	SOLA	SOLA/EMV

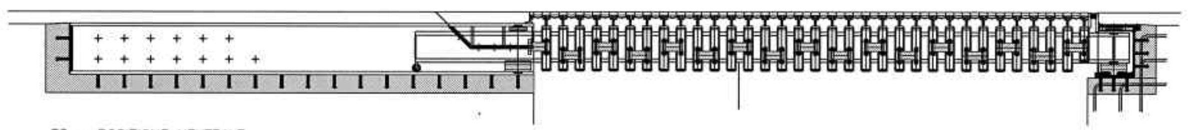
NOME DEL FILE: CG1000-PAXDPCG-S5AP000000-01.DWG — revisione interna:

Appendix 4.2.P - Reference drawing, Expansion Joints

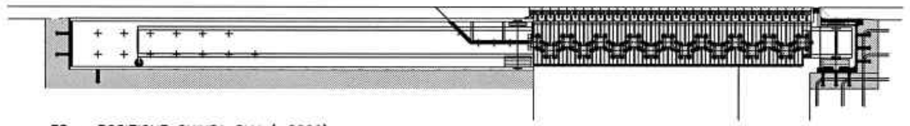
PIANTA
SCALA 1:500
PLAN
SCALE 1:500



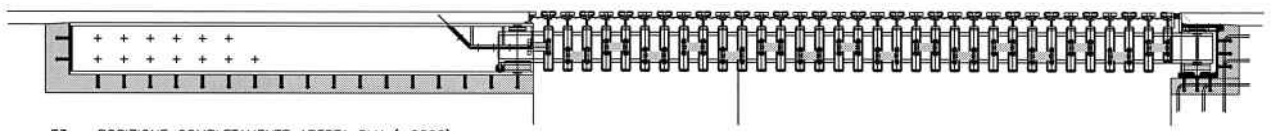
SEZIONE A–A
SECTION A–A



E3 – POSIZIONE NEUTRALE
E3 – NEUTRAL POSITION

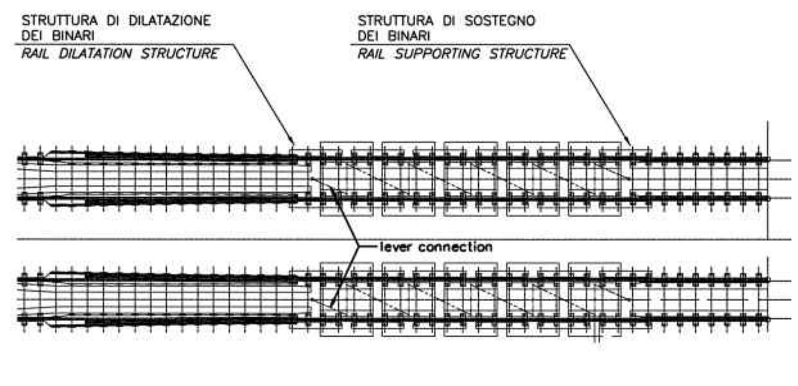


E3 – POSIZIONE CHIUSA SLU (–2000)
E3 – FULLY CLOSED SLU (–2000)



E3 – POSIZIONE COMPLETAMENTE APERTA SLU (+2000)
E3 – FULLY OPEN SLU (+2000)

DETTAGLIO 1
DETAIL 1



E4 – POSIZIONE CENTRALE
E4 – CENTRAL POSITION

HOLD

GIUNTI DI DILATAZIONE STRADALI, SICILIA
ROADWAY EXPANSION JOINTS, SICILIA

		SPOSTAMENTI/ *MOVEMENT* (m)		
		SLS1	SLS2	ULS
E1	LONGITUDINALE/ *LONGITUDINAL*	±0.500	±0.600	±0.800
	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.020
E2	LONGITUDINALE/ *LONGITUDINAL*	±0.100	±0.100	±0.100
	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.020
E3	LONGITUDINALE/ *LONGITUDINAL*	±1.200	±1.400	±2.000
	TRASVERSALE/ *TRANSVERSE*	±0.150	±0.200	±0.400
E6	LONGITUDINALE/ *LONGITUDINAL*	±0.250	±0.400	±0.600
	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.020

GIUNTI DI DILATAZIONE STRADALI, SICILIA
ROADWAY EXPANSION JOINTS, SICILIA

		ROTAZIONI ATTORNO ALL'ASSE (RAD) *ROTATIONS AROUND AXIS*		
		SLS1	SLS2	ULS
E1	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.040
	VERTICALE/ *VERTICAL*	±0.020	±0.020	±0.030
E2	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.040
	VERTICALE/ *VERTICAL*	±0.020	±0.020	±0.030
E3	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.030	±0.040
	VERTICALE/ *VERTICAL*	±0.002	±0.003	±0.004
E6	TRASVERSALE/ *TRANSVERSE*	±0.005	±0.010	±0.015
	VERTICALE/ *VERTICAL*	±0.002	±0.003	±0.004

GIUNTI DI DILATAZIONE STRADALI, CALABRIA
ROADWAY EXPANSION JOINTS, CALABRIA

		SPOSTAMENTI/ *MOVEMENT* (m)		
		SLS1	SLS2	ULS
E1	LONGITUDINALE/ *LONGITUDINAL*	±0.500	±0.600	±0.800
	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.020
E2	LONGITUDINALE/ *LONGITUDINAL*	±0.100	±0.100	±0.100
	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.020
E3	LONGITUDINALE/ *LONGITUDINAL*	±1.200	±1.400	±2.000
	TRASVERSALE/ *TRANSVERSE*	±0.150	±0.200	±0.400
E8	LONGITUDINALE/ *LONGITUDINAL*	±0.100	±0.200	±0.400
	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.020

GIUNTI DI DILATAZIONE STRADALI, CALABRIA
ROADWAY EXPANSION JOINTS, CALABRIA

		ROTAZIONI ATTORNO ALL'ASSE (RAD) *ROTATIONS AROUND AXIS*		
		SLS1	SLS2	ULS
E1	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.040
	VERTICALE/ *VERTICAL*	±0.020	±0.020	±0.030
E2	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.020	±0.040
	VERTICALE/ *VERTICAL*	±0.020	±0.020	±0.030
E3	TRASVERSALE/ *TRANSVERSE*	±0.020	±0.030	±0.040
	VERTICALE/ *VERTICAL*	±0.002	±0.003	±0.004
E6	TRASVERSALE/ *TRANSVERSE*	±0.005	±0.010	±0.015
	VERTICALE/ *VERTICAL*	±0.002	±0.003	±0.004

GIUNTI DI DILATAZIONE FERROVIARI, SICILIA
RAILWAY EXPANSION JOINTS, SICILIA

		SPOSTAMENTI/ *MOVEMENT* (m)		
		SLS1	SLS2	ULS
E4	LONGITUDINALE/ *LONGITUDINAL*	±1.200	±1.400	±2.000
	TRASVERSALE/ *TRANSVERSE*	±0.002	±0.002	±0.002
E5	LONGITUDINALE/ *LONGITUDINAL*	±0.250	±0.400	±0.600
	TRASVERSALE/ *TRANSVERSE*	±0.002	±0.002	±0.002

GIUNTI DI DILATAZIONE FERROVIARI, SICILIA
RAILWAY EXPANSION JOINTS, SICILIA

		ROTAZIONI ATTORNO ALL'ASSE (RAD) *ROTATIONS AROUND AXIS*		
		SLS1	SLS2	ULS
E4	TRASVERSALE/ *TRANSVERSE*	±0.002	±0.004	±0.006
	VERTICALE/ *VERTICAL*	±0.003	±0.005	±0.010
E5	TRASVERSALE/ *TRANSVERSE*	±0.002	±0.003	±0.004
	VERTICALE/ *VERTICAL*	±0.002	±0.003	±0.004

GIUNTI DI DILATAZIONE FERROVIARI, CALABRIA
RAILWAY EXPANSION JOINTS, CALABRIA

		SPOSTAMENTI/ *MOVEMENTS* (m)		
		SLS1	SLS2	ULS
E4	LONGITUDINALE/ *LONGITUDINAL*	±1.200	±1.400	±2.000
	TRASVERSALE/ *TRANSVERSE*	±0.002	±0.002	±0.002
E7	LONGITUDINALE/ *LONGITUDINAL*	±0.100	±0.200	±0.400
	TRASVERSALE/ *TRANSVERSE*	±0.002	±0.002	±0.002

GIUNTI DI DILATAZIONE FERROVIARI, CALABRIA
RAILWAY EXPANSION JOINTS, CALABRIA

		ROTAZIONI ATTORNO ALL'ASSE (RAD) *ROTATIONS AROUND AXIS*		
		SLS1	SLS2	ULS
E4	TRASVERSALE/ *TRANSVERSE*	±0.002	±0.004	±0.006
	VERTICALE/ *VERTICAL*	±0.003	±0.005	±0.010
E7	TRASVERSALE/ *TRANSVERSE*	±0.002	±0.003	±0.004
	VERTICALE/ *VERTICAL*	±0.002	±0.003	±0.004

NOTE GENERALI

NOTE:
DIMENSIONI: TUTTE LE DIMENSIONI SONO IN MILLIMETRI, SALVO OVE DIVERSAMENTE INDICATO.

ELABORATI DI RIFERIMENTO:

NOTES:
DIMENSIONS: DIMENSIONS ARE IN MILLIMETRE UNLESS OTHERWISE NOTED.

REFERENCES:

Stretto di Messina

Concessionaria per la progettazione, realizzazione e gestione del collegamento stabile tra la Sicilia e il Continente
Organismo di Diritto pubblico
(Legge n° 1158 del 17 dicembre 1971, modificata dal D.Lgs. n° 114 del 24 aprile 2003)

Eurolink

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a.r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

IL PROGETTISTA PROJECT MANAGER (Ing. E.M. Veje) COWI DATA______	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE (Dott. Ing..............) DATA______	IL CONTRAENTE GENERALE PROJECT MANAGER (Ing. P.P. Marcheselli) DATA______	STRETTO DI MESSINA DATA______

OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
SISTEMA DI ARTICOLAZIONE
SCHEMA GIUNTI GENERALE

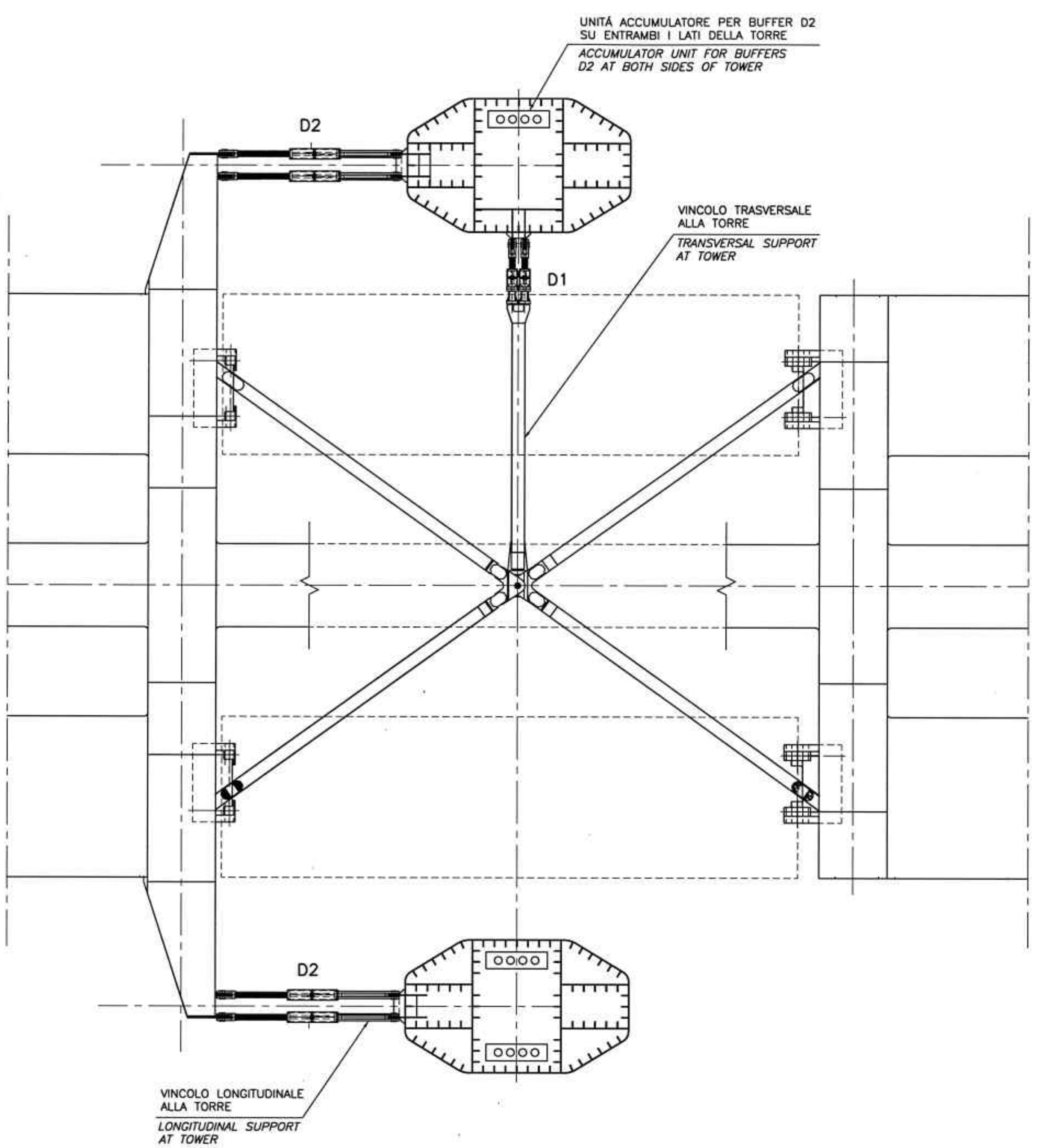
CODICE C G 1 0 0 0 P A X D P C G S 5 G E 0 0 0 0 0 0 0 1 A SCALA: VARIE

REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	26-07-2010	EMISSIONE	CHPP/HPJE	SOLA	SOLA/EMV

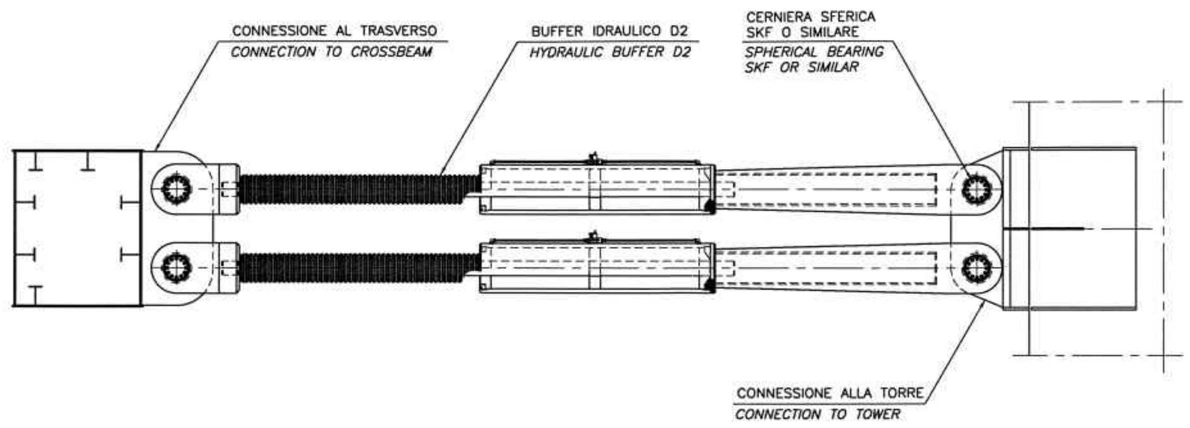
NOME DEL FILE:CG1000-PAXDPCG-S5GE000000-01.DWG
revisione interna:

Appendix 4.2.Q - Reference drawing, Hydraulic buffers, D1 and D2

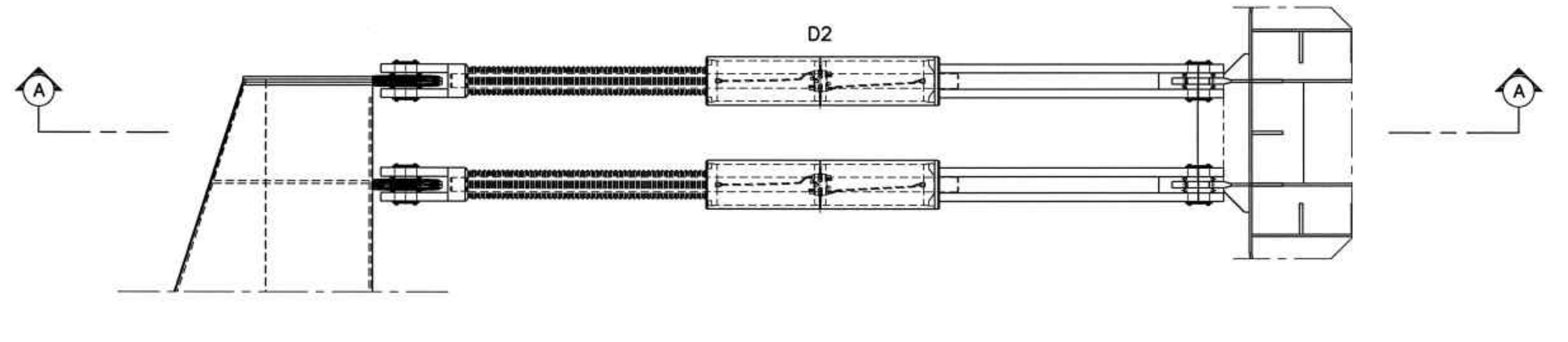
CONFIGURAZIONE DEI VINCOLI ALLA TORRE
SCALA 1:200
SUPPORT ARRANGEMENT AT TOWER
SCALE 1:200



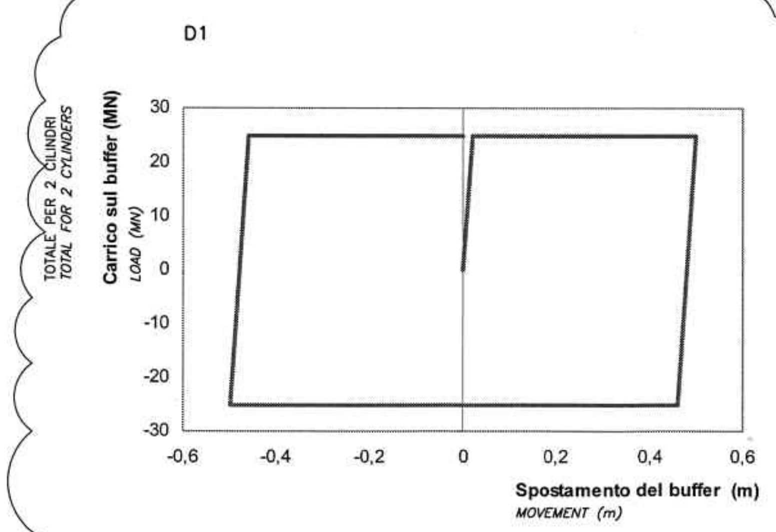
SEZIONE A–A
SCALA 1:50
SECTION A–A
SCALE 1:50



VINCOLO LONGITUDINALE DELL'IMPALCATO
SCALA 1:50
LONGITUDINAL SUPPORT OF BRIDGE DECK
SCALE 1:50



HOLD



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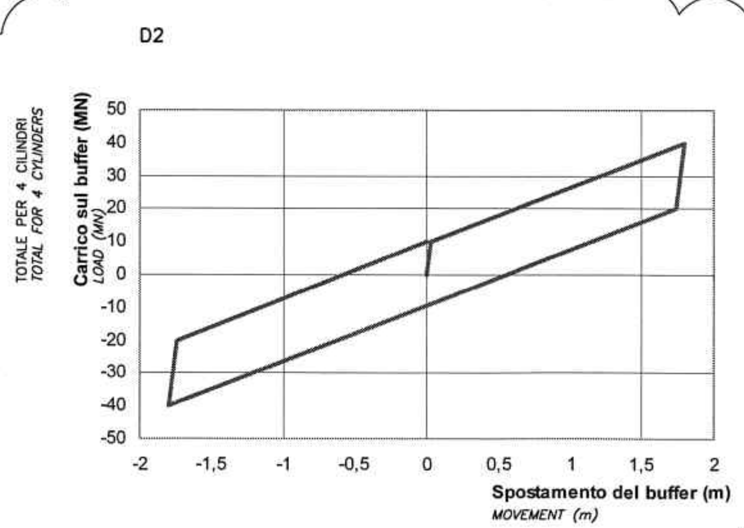


HOLD

SPOSTAMENTI RELATIVI DELL'IMPALCATO
GIRDER MOVEMENTS RELATIVE TO THE TOWER

	SPOSTAMENTI (m) *MOVEMENT*		
	SLS1	SLS2	ULS
SPOSTAMENTO ORIZZONTALE VERSO LA CAMPATA LATERALE *HORIZONTAL MOVEMENT TOWARDS SIDE SPAN*	1.200	1.400	1.800
SPOSTAMENTO ORIZZONTALE VERSO LA CAMPATA PRINCIPALE *HORIZONTAL MOVEMENT TOWARDS MAIN SPAN*	1.200	1.400	1.800
SPOSTAMENTO ORIZZONTALE TRASVERSALE *HORIZONTAL MOVEMENT TRANSVERSAL*	0.050	0.050	0.500
SPOSTAMENTO VERTICALE VERSO L'BASSO *VERTICAL MOVEMENT DOWNWARDS*	1.200	1.550	2.100
SPOSTAMENTO VERTICALE VERSO L'ALTO *VERTICAL MOVEMENT UPWARDS*	0.200	0.400	0.700

ROTAZIONE NEI BUFFERS
ROTATION IN BUFFERS

		ROTAZIONI ATTORNO ALL'ASSE (RAD) *ROTATION AROUND AXIS*		
		SLS1	SLS2	ULS
D1	VERTICALE *VERTICAL*	±0.040	±0.050	±0.060
	LONGITUDINALE *LONGITUDINAL*	±0.040	±0.060	±0.070
	TRASVERSALE *TRANSVERSE*	±0.010	±0.020	±0.030
D2	VERTICALE *VERTICAL*	±0.040	±0.050	±0.060
	LONGITUDINALE *LONGITUDINAL*	±0.050	±0.060	±0.070
	TRASVERSALE *TRANSVERSE*	±0.200	±0.250	±0.300

Stretto di Messina

Eurolink

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

IL PROGETTISTA PROJECT MANAGER	INTEGRAZIONE PRESTAZIONI SPECIALISTICHE	IL CONTRAENTE GENERALE PROJECT MANAGER	STRETTO DI MESSINA
(Ing. E.M. Veje) COWI	(Dott. Ing.............)	(Ing. P.P. Marcheselli)	
DATA	DATA	DATA	DATA

OPERA DI ATTRAVERSAMENTO
CONCEZIONE/DIMENSIONAMENTO GENERALE E DISEGNI D'ASSIEME
SOVRASTRUTTURE
SISTEMA DI ARTICOLAZIONE
CONNESSIONE TRA IMPALCATO E TORRE

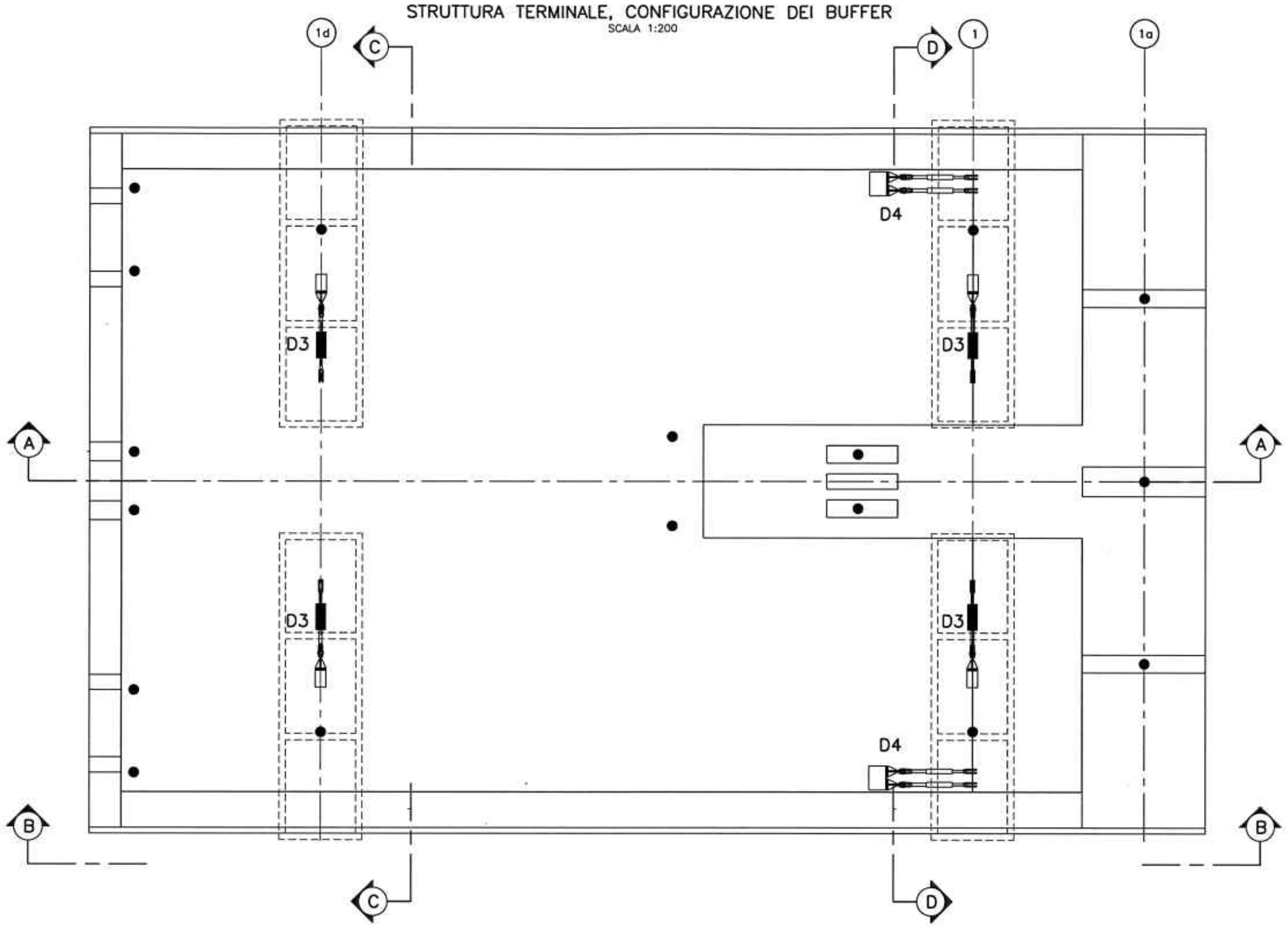
CODICE C G 1 0 0 0 P A X D P C G S 5 A M 0 0 0 0 0 0 0 2 A — SCALA: VARIE

REV.	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
A	20-06-2010	EMISSIONE	CHPP/HPJE	SOLA	SOLA/ENV

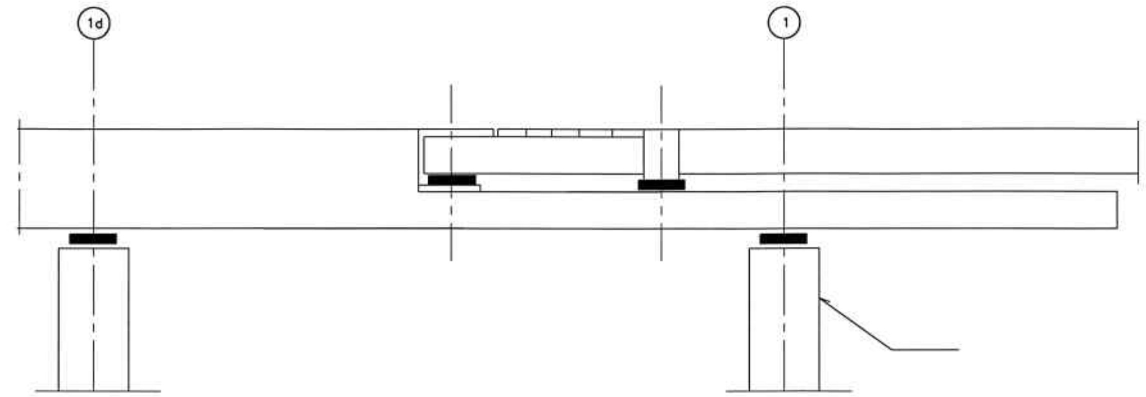
NOME DEL FILE: CG1000-PAXDPCG-S5AM000000-02.DWG — revisione interna:

Appendix 4.2.R - Reference drawing, Hydraulic buffers, D3 and D4

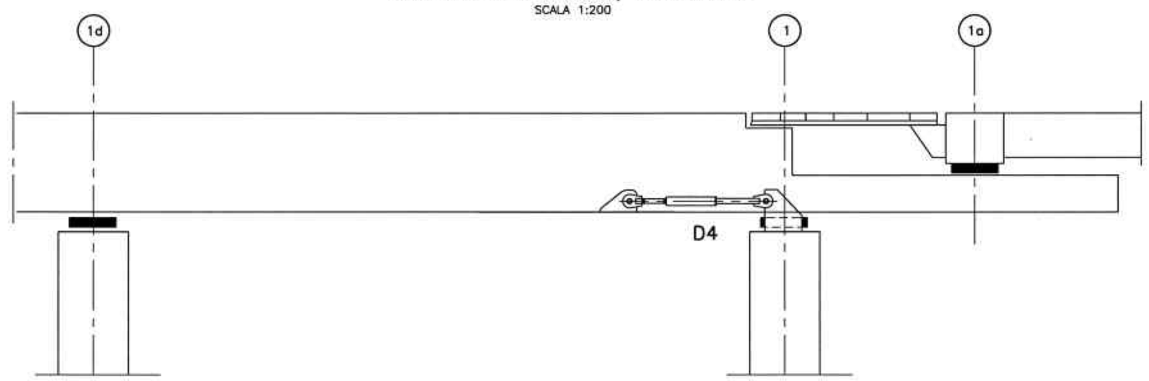
STRUTTURA TERMINALE, CONFIGURAZIONE DEI BUFFER
SCALA 1:200



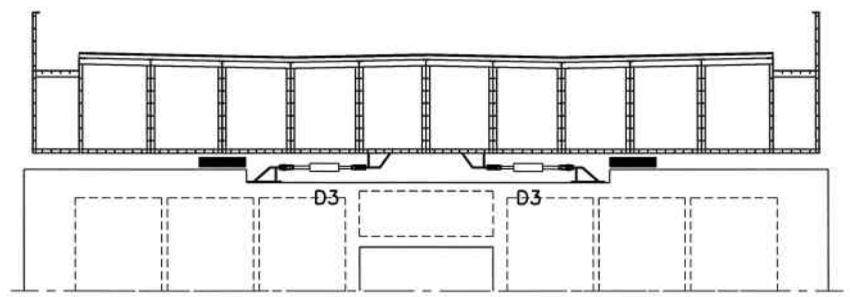
SEZIONE A–A FERROVIA, SCHEMATICA
SCALA 1:200



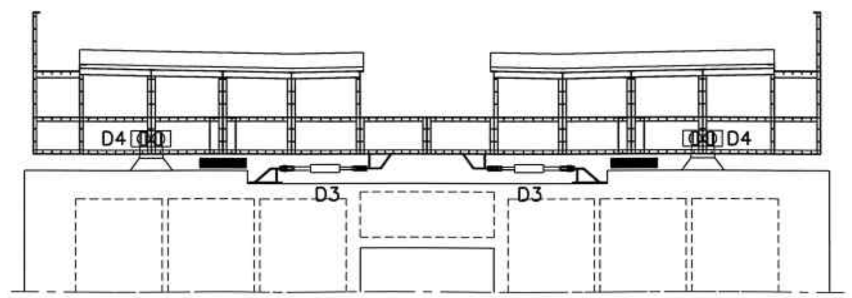
SEZIONE B–B STRADA, SCHEMATICA
SCALA 1:200



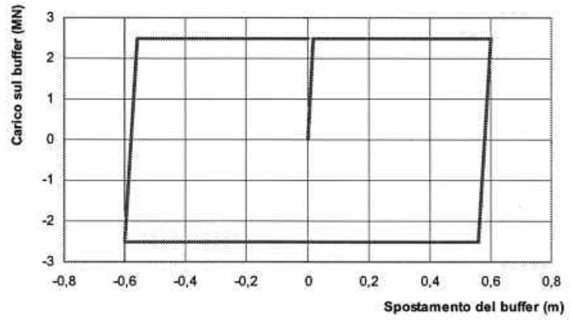
SEZIONE C–C, SCHEMATICA
SCALA 1:200



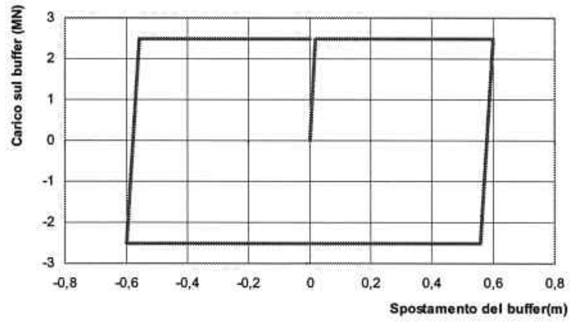
SEZIONE D–D, SCHEMATICA
SCALA 1:200



BUFFER D3



BUFFER D4



Spostamenti relativi dell' impalcato rispetto alle torre		SLS1	SLS2	ULS
Spostamento orrizontale verso la campata laterale	m	0,10	0,30	0,60
Spostamento orrizontale verso la campata principale	m	0,10	0,30	0,60
Spostamento orrizontale trasversale	m	0,10	0,30	0,60
Spostamento verticale verso il basso	m	0,01	0,02	0,04
Spostamento verticale verso l'alto	m	0,01	0,02	0,04

Stretto di Messina

STRETTO DI MESSINA S.p.A – CONCESSIONARIA DI STATO D.I.M. n. 3437/05
LEGGE n. 1158/71 PER UN COLLEGAMENTO STABILE VIARIO E FERROVIARIO TRA LA SICILIA E IL CONTINENTE

PONTE SULLO STRETTO DI MESSINA

PROGETTO DI GARA

ASSOCIAZIONE TEMPORANEA DI IMPRESE
IMPREGILO S.p.A. (Mandataria)
SOCIETA' ITALIANA PER CONDOTTE D'ACQUA S.p.A. (Mandante)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. di Ravenna Soc. Coop. a r.l. (Mandante)
SACYR S.A.U. (Mandante)
ISHIKAWAJIMA - HARIMA HEAVY INDUSTRIES CO. Ltd. (Mandante)
A.C.I. S.C.P.A. - CONSORZIO STABILE (Mandante)

Progettisti

COWI a/s
Buckland & Taylor LTD
Sund & Bælt Partner LTD

Baltimat Srl
IN.CO Ingegneri Consulenti S.p.A.
MCA - advanced Engineering Srl
Sina S.p.A.
Sini Ingegneria Srl
Studio Professionale Associato Ingg. Ferro e Carloni
Prof.ssa La Torre Bellardoni
Uffici Tecnici A.T.I.

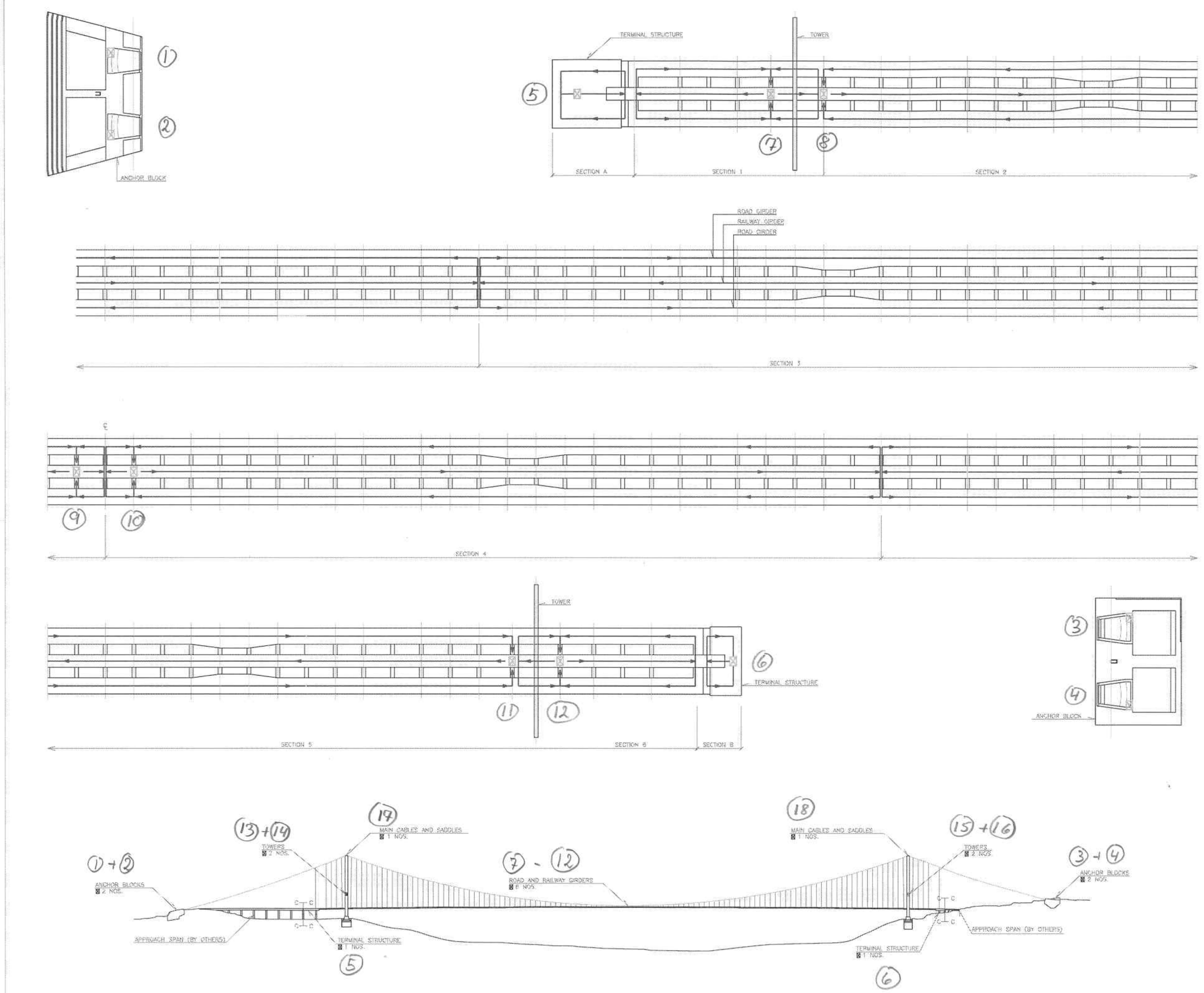
Consulenza e Ricerche
Università degli Studi di Catania - Prof. Lentini
Università degli Studi di Reggio Calabria - Prof. Zagari
Università La Sapienza - Prof. Canadese

PARTE: 2 – IL PONTE ED I SUOI COLLEGAMENTI –

L'OPERA D'ATTRAVERSAMENTO
STRUTTURA TERMINALE
CONFIGURAZIONE DEI BUFFER

ELAB.	PROGETTO PG	PARTE 2 D	CODICE B0-106_1 N08	n° 1	Rev. 0	Scala: -	Data: 05/04/05
Società: COWI	Redatto: SOLA	Controllato: ATI	Approvato: LTS/HHJC				
emo 05-04-2005	Nome File: PG_2D_B0-106_1_N08_1.dgn						

Appendix 4.2.S - Reference Drawing, Dehumidification Plants



NOTE GENERALI

NOTES:

EACH DEHUMIDIFICATION SECTION IS SEPERATE FROM ADJOINING BY MEANS OF AIRTHIGHT DIAPHRAGMS.

LEGEND:

→ AIRFLOW DIRECTION

⊠ LOCATION OF DEHUMIDIFICATION PLANT INCLUDING CONTROL PANEL

1 - 18 DEHUMIDIFICATION PLANT NO.

Stretto di Messina

STRETTO DI MESSINA S.p.A – CONCESSIONARIA DI STATO D.I.M. n. 3437/85
LEGGE n. 1158/71 PER UN COLLEGAMENTO STABILE VIARIO E FERROVIARIO TRA LA SICILIA E IL CONTINENTE

PONTE SULLO STRETTO DI MESSINA

PROGETTO DI GARA

ASSOCIAZIONE TEMPORANEA DI IMPRESE

PARTE: 2 – IL PONTE ED I SUOI COLLEGAMENTI –

L'OPERA D'ATTRAVERSAMENTO
DEHUMIDIFICATION SYSTEM
SYSTEM KEY PLAN

ELAB.	PG	2 D	B 0 – 1 0 6	2 N 0 1	1	0	NO SCALE	2004.03.04
COWI		EIS/JKK		SHA		KPL/HHJC		

Appendix 4.4.A - Component Sheets

COMPONENT SHEET REF: TP 3.01.3.A

Bridge Component Code: Element 1.2.3. (P-SV-I3)(Deck).

Technical Procedure: TP No. 3.01 **TI:** 3.01.3

COMPONENT DESCRIPTION:	
1.2.3.1 (P-SV-I3-CF)	Deck Railway Girder – Internal Surfaces
1.2.3.2 (P-SV-I3-??)	Deck Roadway Girder Sicily -Internal surfaces.
1.2.3.3. (P-SV-I3-??)	Deck Roadway Girder Calabria - Internal surfaces.
1.2.3.4. (P-SV-I3-TP)	Deck Box Cross Girders - Internal surfaces.
INSPECTION:	
2 Yearly	Routine Visual Inspection (Walk through inspection of all surfaces)
6 Yearly	Principal Inspection (close visual inspection of all surfaces)
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS:	From Service Lane through access points into box girders.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS:	
Minor Weld Repairs. Sealing of access points.	
OPERATING RESTRICTIONS:	Hot weather may increase temperature within box sections. Traffic noise may be noticeable, particularly rail traffic.
DESIGN/SERVICE LIFE:	
Steel box girders:	Designed for the life of the Bridge.
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES:	
Steel box section fabricators:	XXX (See sheet ??– External areas)
SPARES:	None

COMPONENT SHEET REF: TP 3.01.3.B

Bridge Component Code: Element 1.2.3. (P-SV-I3)(Deck). Secondary Steel.

Technical Procedure: TP No. 3.01 **TI:** 3.01.3

COMPONENT DESCRIPTION: 1.2.3.1 (P-SV-I3-CF) Deck Railway Girder – Internal Areas – Secondary steelwork. 1.2.3.2 (P-SV-I3-??) Deck Roadway Girder Sicily -Internal Areas – Secondary steelwork. 1.2.3.3. (P-SV-I3-??) Deck Roadway Girder Calabria - Internal Areas – Secondary steelwork. 1.2.3.4. (P-SV-I3-TP) Deck Box Cross Girders - Internal Areas – Secondary steelwork.	
INSPECTION: 2 Yearly Routine Visual Inspection. 6 Yearly Principal Inspection (close visual inspection)	
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS:	From Service Lane through access points into box girders.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS: Minor Repairs, bolt tightening.	
OPERATING RESTRICTIONS: Hot weather may increase temperature within box sections. Traffic noise may be noticeable, particularly rail traffic.	
DESIGN/SERVICE LIFE: Secondary steelwork: Designed for the life of the Bridge.	
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES: Secondary steelwork fabricators: Await details.	
SPARES:	None.

COMPONENT SHEET REF: TP 3.01.3.C

Bridge Component Code: Element 1.2.3. (P-SV-I3)(Deck). Access Manholes.

Technical Procedure: TP No. 3.01 **TI:** 3.01.3

COMPONENT DESCRIPTION:	
1.2.3.1 (P-SV-I3-CF)	Deck Railway Girder – Internal Areas – Access manholes.
1.2.3.2 (P-SV-I3-??)	Deck Roadway Girder Sicily -Internal Areas – Access manholes.
1.2.3.3. (P-SV-I3-??)	Deck Roadway Girder Calabria - Internal Areas – Access manholes.
1.2.3.4. (P-SV-I3-TP)	Deck Box Cross Girders - Internal Areas – Access manholes.
INSPECTION:	
2 Yearly	Routine Visual Inspection.
6 Yearly	Principal Inspection (close visual inspection)
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection**.**
MEANS OF ACCESS:	From Service Lane through access points into box girders.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS:	
Minor Repairs, grease hinges, check locks and seals.	
OPERATING RESTRICTIONS:	Hot weather may increase temperature within box sections.
Traffic noise may be noticeable, particularly rail traffic.	
DESIGN/SERVICE LIFE:	
Access manholes:	Designed for the life of the Bridge.
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES:	
Access manhole fabricators:	Await details.
SPARES:	Locks and keys may be considered.

COMPONENT SHEET REF: TP 3.01.4.A

Bridge Component Code: Element 1.2.3. (P-SV-I3)(Deck).

Technical Procedure: TP No.3.01 **TI:** 3.01.4

COMPONENT DESCRIPTION: 1.2.3.1 (P-SV-I3-CF) Deck Railway Girder - external painted surfaces and platforms. 1.2.3.2 (P-SV-I3-??) Deck Roadway Girder Sicily - external surfaces. 1.2.3.3. (P-SV-I3-??) Deck Roadway Girder Calabria - external surfaces. 1.2.3.4. (P-SV-I3-TP) Deck Box Cross Girders - external surfaces.	
INSPECTION: 2 Yearly Routine Visual Inspection 6 Yearly Principal Inspection (close visual inspection of all surfaces) **Reliability Based Inspections (RBI)** Assessment for renewal of top coat of painted structural steelwork. 4 Yearly Reliability Based Special Inspection (RBI) of selected representative areas At year 16 Reliability Based Principal Inspection of painted surfaces	
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection**.**
MEANS OF ACCESS:	Using side tracks and travelling maintenance gantries.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS: Patch painting. Minor Weld Repairs	
OPERATING RESTRICTIONS: Dictated by gantry operations.	
DESIGN/SERVICE LIFE: Steel box girders: Paint system: Gantry runway beams:	 Designed for the life of the Bridge. Top Coat 20 years – assessed by RBI. Replaceable elements.
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES: Steel box section fabricators: Paint systems:	 XXX (See sheet ?? – internal areas) Refer to Data Sheets. Ref: XX

SPARES:	None

COMPONENT SHEET REF: TP 3.01.4.B

Bridge Component Code: Element 1.3.1.2. (P-SS-R4-BF) (Wind Screens)

Technical Procedure: TP No. 3.01 **TI:** 3.01.4

COMPONENT DESCRIPTION: 1.3.1.2 (P-SS-R4-BF) Bridge Secondary Structures – Wind Screens	
INSPECTION: 2 Yearly Routine Visual Inspection 6 Yearly Principal Inspection (close visual inspection of all surfaces and fixings) Refer to manufacturer's product sheet for details of additional inspection requirements.	
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS:	Using side tracks and travelling maintenance gantries.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS: Galvanising expected to last for 50 years. Refer to manufacturer's product sheet for details of additional requirements.	
OPERATING RESTRICTIONS: Dictated by gantry operations.	
DESIGN/SERVICE LIFE: Wind Screens: Designed for the life of the Bridge. Paint system: Minor Maintenance XX years, Repaint after YY years.	
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES: Wind Screen Suppliers To be included. Paint systems: Refer to Data Sheets. Ref: XX	
SPARES: A small number of spare posts, rails and fixings should be considered.	

COMPONENT SHEET REF: TP 3.01.4.C

Bridge Component Code: Element 1.3.1.1. (P-SS-R4-CR) (Service Lane)

Technical Procedure: TP No. 3.01 **TI:** 3.01.4

COMPONENT DESCRIPTION: 1.3.1.1 (P-SS-R4-CR) Bridge Secondary Structures – Service Lane (Deck panels)	
INSPECTION: 2 Yearly Routine Visual Inspection 6 Yearly Principal Inspection (close visual inspection of all surfaces and fixings) Refer to manufacturer's product sheet for details of additional inspection requirements.	
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS:	Using side tracks and travelling maintenance gantries.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS: Refer to manufacturer's product sheet for details of requirements.	
OPERATING RESTRICTIONS: Dictated by gantry operations.	
DESIGN/SERVICE LIFE: Deck panels: Designed for the life of the Bridge.	
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES: Deck Panel Suppliers To be included.	
SPARES: A small number of spare deck panels should be considered.	

COMPONENT SHEET REF: TP 3.02.1.A

Bridge Component Code: Element 1.2.2.4.1. (P-SV-S7-CA))(Main Cable).

Technical Procedure: TP No. 3.02 **TI:** 3.02.1

COMPONENT DESCRIPTION: 1.2.2.4.1. Main Suspension cables. 1.2.2.4.1.1-4.3. Wrapping membrane to main cables	
INSPECTION: 3 Monthly Routine Superficial Inspection from Road level and tower top. 2 Yearly Routine General Inspection from main cable walkway (Alternate at 1 year). 6 Yearly Principal Inspection from Access Gantries (Alternate at 3 years).	
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS:	As noted above.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS: Procedure for patch repairs of wrapping membrane to be developed.	
OPERATING RESTRICTIONS: Weather restrictions to be determined for access to main cable.	
DESIGN/SERVICE LIFE: Main cable: Designed for the life of the Bridge. Wrapping: Up to 30 years with possible patch repairs.	
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES: Main Cable: XX Wrapping Membrane: YY	
SPARES:	Patch repair kit for minor repairs to neoprene wrapping.

COMPONENT SHEET REF: TP 3.02.1.B

Bridge Component Code: Element 1.2.2.1. (P-SV-S7-C0))(Cable Clamps).

Technical Procedure: TP No. 3.02 **TI:** 3.02.1

COMPONENT DESCRIPTION: 1.2.2.1.1-3.n.1 . Cable clamp castings 1.2.2.1.1-3.n.2. Cable clamp bolts 1.2.2.1.1-3.n.3. Cable clamp seals	
INSPECTION: 3 Monthly Routine Superficial Inspection from Road level and tower top. 2 Yearly Routine General Inspection from main cable walkway (Alternate at 1 year). 6 Yearly Principal Inspection from Access Gantries as appropriate (Alternate at 3 years).	
MEASUREMENTS: None as routine but cable clamp bolt lengths/tensions may need to be checked under Special Inspections.	
MAINTENANCE: As a result of inspection.	
MEANS OF ACCESS: As noted above.	
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS: Procedure for sealant repair/replacement to be developed. Requirement for bolt tension checking to be determined. Patch paint repairs of clamps.	
OPERATING RESTRICTIONS: Weather restrictions to be determined for access to main cable.	
DESIGN/SERVICE LIFE: Cable clamps: Designed for life of the bridge. Bolts: Designed for life of the bridge. Sealant: c25 years.	
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES: Cable clamps: XX Bolts: YY Sealant: ZZ	
SPARES:	Sealant repair kit. Consider storing a small number of cable clamp bolts (c12).

COMPONENT SHEET REF: TP 3.02.1.C

Bridge Component Code: Element 1.2.2.3. (P-SV-S7-PE))(Hangers).

Technical Procedure: TP No. 3.02 **TI:** 3.02.1

COMPONENT DESCRIPTION: 1.2.2.3.1-3.n.1. HDPE sheaths 1.2.2.3.1-3.n.2. Steel wires 1.2.2.3.1-3.n.3. Hanger Sockets 1.2.2.3.1-3.n.4. Upper connections 1.2.2.3.1-3.n.5. Lower Connections 1.2.2.3.1-3.n.6. Dampers/spacers	
INSPECTION: 3 Monthly Routine Superficial Inspection from Road level and tower top. 2 Yearly Routine General Inspection from road level and the main cable walkway (Alternate at 1 year). 6 Yearly Principal Inspection from Access Gantries as appropriate (Alternate at 3 years).	
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS: As noted above.	
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS: Procedure for patch repair of HDPE covering. Patch paint repairs of sockets and attachments.	
OPERATING RESTRICTIONS: Weather restrictions to be determined for access to main cable.	
DESIGN/SERVICE LIFE: All parts : up to 60 years	
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES: Hangers, sockets, pins: XX Bearings: YY	
SPARES:	Patch repair kit for damage to HDPE sheaths Spare attachments – dampers/spacers

COMPONENT SHEET REF: TP 3.02.1.D

Bridge Component Code: Element 1.2.2.5. (P-SV-S7-??))(Handstrand Ropes).

Technical Procedure: TP No. 3.02 **TI:** 3.02.1

COMPONENT DESCRIPTION:	
1.2.2.5.1.1-4.1.	Outer Handstrand Ropes (50mm)
1. 2.2.5.1.1-4.1.	Inner Handstrand Ropes (25mm)
1. 2.2.5.1.1-4.1.	Support Posts and Clamps
1. 2.2.5.1.1-4.1.	Rope Anchorages – Deck Level
1. 2.2.5.1.1-4.1.	Rope Anchorages – Tower Tops
INSPECTION:	
3 Monthly	Routine Superficial Inspection from Road level and tower top.
2 Yearly	Routine General Inspection from main cable walkway (Alternate at 1 year).
6 Yearly	Principal Inspection from Access Gantries (Alternate at 3 years).
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS:	As noted above.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS:	
Corrosion protection to ropes.	
Patch paint repairs.	
OPERATING RESTRICTIONS: Weather restrictions to be determined for access to main cable.	
DESIGN/SERVICE LIFE:	
Ropes and sockets:	Up to 30 years.
Posts and clamps:	Designed for the life of the Bridge.
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES:	
Ropes and sockets:	XX
Posts and clamps:	YY
SPARES:	Check replacement lead times but consider a number (4?) of spare posts are stored in case of damage to these bridge parts in service.

COMPONENT SHEET REF: TP 3.02.1.E

Bridge Component Code: Element 1.2.2.2. (P-SV-S7-SL-ST))(Tower Saddles).

Technical Procedure: TP No. 3.02 **TI:** 3.02.1

COMPONENT DESCRIPTION:	
1.2.2.2.2.	Tower Saddles
INSPECTION:	
2 Yearly	Routine General Inspection at Tower Top (Alternate at 1 year).
6 Yearly	Principal Inspection at Tower Top (Alternate at 3 years).
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS:	As noted above.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS:	
Patch paint repairs.	
OPERATING RESTRICTIONS: Weather restrictions to be determined for access to tower top.	
DESIGN/SERVICE LIFE:	
Saddles:	Designed for the life of the Bridge.
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES:	
Tower Top Saddles:	XX
SPARES:	None

COMPONENT SHEET REF: TP 3.02.2.A

Bridge Component Code: Element 1.2.2.2. (P-SV-S7-SL-SA))(Splay Saddles).

Technical Procedure: TP No. 3.02 **TI:** 3.02.2

COMPONENT DESCRIPTION: 1.2.2.2.1. Splay Saddles in anchorage chambers	
INSPECTION: 2 Yearly Routine General Inspection within anchorages (Alternate at 1 year). 6 Yearly Principal Inspection within anchorages (Alternate at 3 years).	
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS:	As noted above.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS: None	
OPERATING RESTRICTIONS:	None
DESIGN/SERVICE LIFE: Splay Saddles:	 Designed for the life of the Bridge.
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES: Splay Saddles:	 XX
SPARES:	None

COMPONENT SHEET REF: TP 3.02.2.B

Bridge Component Code: Element 1.2.2.4. (P-SV-S7-CA))(Main cables at anchor blocks).

Technical Procedure: TP No. 3.02   **TI:** 3.02.2

COMPONENT DESCRIPTION:	
1.2.2.4.1.1-4.2.	Main cable inside anchor blocks.
1.2.2.4.1.1-4.4.	Cross head plate inside anchor blocks.
1.2.2.4.1.1-4.5.	Anchor rods inside anchor blocks.
1.2.2.4.1.1-4.6.	Upper anchor plate inside anchor blocks.
1.2.2.4.1.1-4.7.	Anchor bolts inside anchor blocks.
INSPECTION:	
2 Yearly	Routine General Inspection within anchorages (Alternate at 1 year).
6 Yearly	Principal Inspection within anchorages (Alternate at 3 years).
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection.
MEANS OF ACCESS:	As noted above.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS:	
None	
OPERATING RESTRICTIONS:	None
DESIGN/SERVICE LIFE:	
Cable and anchorage components:	Designed for the life of the Bridge.
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES:	
Main Cables:	Refer to Component Sheet TP YY - TI 01 – 01.
Cross head plate:	XX
Anchor rods:	YY
Upper anchor plate:	ZZ
Anchor bolts:	QQ
SPARES:	None

<u>COMPONENT SHEET REF: TP 3.02.2.C</u>

Bridge Component Code: Element 1.2.2.4.1.1-4.8??. (P-SV-S7-CA). (Secondary Steel in anchor blocks).

Technical Procedure: TP No. 3.02 **TI:** 3.02.2

COMPONENT DESCRIPTION: 1.2.2.4.1.1-4.8??. Main cable –Anchor block, Internal Areas – Secondary steelwork.	
INSPECTION: 2 Yearly Routine Visual Inspection. 6 Yearly Principal Inspection (close visual inspection)	
MEASUREMENTS:	None
MAINTENANCE:	As a result of inspection**.**
MEANS OF ACCESS:	As noted above.
MAINTENANCE PROVISION / SPECIAL REQUIREMENTS: Minor Repairs, bolt tightening.	
OPERATING RESTRICTIONS:	
DESIGN/SERVICE LIFE: Secondary steelwork:	Designed for the life of the Bridge.
DRAWING REFERENCES:	
SUB CONTRACTORS/PRODUCTS / MANUFACTURERS REFERENCES: Secondary steelwork fabricators: Await details.	
SPARES: None.	

Appendix 5.10.A - Technical Procedure for inspection and maintenance of Bridge Suspension System

Technical Procedure No. 3.02: Element 1.2.2. (P-SV-S7) Suspension system

TECHNICAL PROCEDURE FOR INSPECTION AND MAINTENANCE OF BRIDGE SUSPENSION SYSTEM DRAFT

1. Purpose

This Technical Procedure describes the inspection and maintenance activities that are required for the suspension system of the Messina Strait Bridge. The procedure is provided to set out the inspection and maintenance activities necessary to ensure that these elements of the bridge are maintained such that their function is assured, throughout the bridge design life, without the need for unplanned corrective maintenance works.

This procedure sets out the requirements for the following categories of Inspection:

a) Routine Inspections
b) Principal Inspections
c) Special Inspections

The procedure covers those bridge parts listed under Section 2 below. However, the following parts will be accessed during aspects of the inspections and consideration should be given to inspecting such parts concurrently:

e.g. Secondary Steelwork, i.e. Access stairs and platforms in the anchorage chambers – TI to be developed for these parts.

2. Validity of the Technical Procedure

This procedure relates to the bridge suspension system and includes the following bridge elements:

Element 1.2.2.1. Cable Clamps

Element 1.2.2.2. Tower Saddles

Element 1.2.2.3. Hangers

Element 1.2.2.4. Main Cables

Element 1.2.2.5. Handstrand Ropes

Element 1.2.2.2.1.	Splay Saddles
Element 1.2.2.4.1.1-4.2.	Main Cables inside Anchor Blocks.
Element 1.2.2.4.1.1-4.4.	Cross head plates inside Anchor Blocks.
Element 1.2.2.4.1.1-4.5.	Anchor rods inside Anchor Blocks.
Element 1.2.2.4.1.1-4.6.	Upper anchor plate inside Anchor Blocks.
Element 1.2.2.4.1.1-4.7.	Anchor bolts inside Anchor Blocks.

3. Reference Procedures and Instructions

Prior to commencing work on site, personnel are to ensure that they are familiar with all the associated manuals and procedures that have been developed for safe and effective working on the structure. Not all such documents will be directly relevant to each of the individual tasks but all staff should be familiar with the overall philosophy and background to the inspection and maintenance procedures.

The following documents should therefore be reviewed prior to undertaking the inspections covered by this Technical Procedure:

The Operation and Emergency Manual.

The Inspection and Maintenance Manual.

TPXX Health and safety, including working in confined spaces, PPE. Weather restrictions on access.

TPXX Working procedures for the bridge, e.g. radio operation, site vehicles, access routes.

TPXX Use of access equipment, e.g. gantries, lifts.

TP 1.01 Principal Inspections (and Definitions of defect types, extent and severity ratings).

4. General Description of the System

There are four main cables, arranged in two pairs, with anchorages at the Sicilia side and the Calabria side of the crossing. Each main cable is made up of 325 strands with each strand comprising 127 wires of 5.40mm diameter. Due to slightly higher loading in the side spans, there are eight additional strands per cable on the Sicilia side span and six additional strands per cable on the Calabria side span. These additional strands are positioned on the upper face of the main cables with their upper ends anchored at the tower top.

The 325 (+8 or +6) strands of the main cables are anchored in the splay chamber within the anchor block. The anchorage arrangements are aligned to match with the detailed geometry of the splay saddles. At both ends of the tie rods a spherical seating is provided to ensure the most favourable alignment of the bolt within the anchorage.

Between the anchorage entry points, a variety of cast steel cable clamps are positioned, these clamps incorporate the fixing point for the upper end of the bridge suspension cables (hangers). The cable clamp detail varies along the length of the cable depending upon the angle of the main cable and the hanger arrangement. Fixed to these clamps are support posts for the handstrand ropes, one pair of handstrands runs above each of the four main cables. The handstrand ropes on each pair of main cables are XX mm diameter and these four ropes are used as support and running rails for the main cable access gantries.

The tower saddles provide vertical support of the main cables on the tower tops. The depth of the grooves, provided for the strands in the cast steel trough plates, increases towards the ends of the saddle in order to allow for the main cable strands to move freely at the saddle ends.

The splay saddles within the anchorage chambers facilitate the spreading of strands to allow them to be anchored. The splay saddle combines welded thick plates and cast steel and is able to 'rock' at the curved bearing surface of the support point.

Corrosion protection to the main cables is composed of dry air flow through the cables (dehumidification) with an elastomeric wrap around the outer surface of the cable in addition to the galvanising of the individual main cable wires. Dry air is produced in buffer tanks and injected into the main cables where it flows to exhaust points. (The inspection and maintenance of the dehumidification system is not included as part of this TP; this is included in TP 6.02)

The elastomeric wrap is applied under tension with a wrapping machine with a 50% overlap and has a total thickness of 2 x 1.1 = 2.2mm. After wrapping, the neoprene is heated by a heating blanket which bonds the two layers and shrinks the wrap slightly thus providing a snug fit and a complete sealing of the cables. The elastomeric wrap requires no maintenance and, if damaged, can be repaired using a heat-bonded patch. Renewal is anticipated to become necessary after 30 years. The upper surface of the neoprene wrapping is reinforced to allow maintenance personnel to walk along the main cables without damaging the wrapping.

All hanger cables are enclosed in HDPE sheaths with no maintenance envisaged for a period of at least 60 years. The spherical bearings that are included for the shortest hangers along the main span are also expected to have a life of at least 60 years. Some hangers are expected to be fitted with bend limiters and some hangers may have dampers fitted to reduce vibrations.

The parts covered by this TP are substantial elements where the manner of inspection will be extremely repetitive. For this reason the application of Reliability Based Inspection (RBI) principles is recommended. RBI covers systems and elements with a predictable failure pattern, where the degradation rate can be measured and is particularly beneficial for multiple repetitive elements.

Under RBI, Special Inspections are undertaken on a number of representative areas where close visual inspections and specific testing and measurements can be carried out to produce a condition indicator. The other areas are inspected less thoroughly, e.g. visual inspection, sufficient to identify any large deviations from the standard of the selected reference areas. One example of RBI would be the paint system applied to the cable clamps; it is presently envisaged that the top coat should be replaced after twenty years. If a number of reference areas could be identified and subjected to a Special Inspection every four years, then in time, the rate of degradation could be assessed and an accurate estimate made of the projected optimum time for the top coat to be renewed. RBI principles could also be applied to the cable clamp bolt tensions and the caulking and sealing of the cable clamps and degradation of the elastomeric wrapping material.

The application of RBI can also justify an increase in the periods between Principle Inspections for particular items.

5. Historical Reference Documents

Prior to undertaking the inspections covered by the Technical Procedure, managers and inspection staff should have access to and be familiar with the following:

- Previous inspection records of the associated parts.
- Construction records, data sheets etc for the associated products and materials.
- Associated sections of the bridge construction stage specifications.
- Records of changes to or clarifications of the specification during construction.
- Records of any associated non-conformances recorded during construction.
- Construction as-built drawings, reports, testing, certification and acceptance records.

These records will need to be developed and maintained during the construction phase. These should be compiled as an Appendix to this Procedure. See Appendix 1.

6. Specialist equipment

When planning the inspections covered by the Technical Procedure, the following specialist equipment may be required. The Technical Manager is to ensure that the necessary equipment is available and, if necessary, calibrated for the period of the inspection. The associated Technical Instructions should also be reviewed to ensure all other necessary equipment is identified.

- Patch repair kit for elastomeric wrapping damage (main cable).
- Patch repair kit for HDPE (hangers).

- Cable clamp sealant.
- Ultrasonic equipment for cable clamp bolt measurements, or
- Cable access gantries
- Others

7. Responsibility

The Technical Manager is responsible for the maintenance of this Technical Procedure and the associated Technical Instructions. The Technical Manager has the overall responsibility for ensuring that this procedure is followed and incorporated into the Activity Plan.

The relevant Inspection and Maintenance Team Leader has responsibility for planning, activating and managing the activities in accordance with the Activity Plan. After completion of the activity the Team Leader ensures that the necessary report is prepared in line with the particular instruction.

The Technical Manager will review all reports and determine any follow up action required. The reports will also be used to assess the rate of wear or deterioration of the bridge elements to enable effective planning of repair or replacement work. This will allow accurate cost forecasting and ensure that specialist spare parts or equipment can be sourced in good time.

The Team Leader has responsibility for ensuring that all persons undertaking inspection and maintenance work are familiar with the operational and safety procedures associated with their tasks and that the necessary notices and permissions have been issued.

8. Description of Activities

The following Technical Instructions have been developed for the inspection and maintenance of the bridge parts associated with this Technical Procedure:

- TI 3.02.1 Main Cables and associated items External Areas
- TI 3.02.2 Main cables and anchorages within anchor blocks.

The bridge parts have been grouped into these Technical Instructions to facilitate effective inspection of the components making up the bridge suspension system. These Technical Instructions may be reviewed and revised to allow alternative bridge element groupings if required by the Technical Manager.

Routine inspections will be of two types, superficial and general. Routine Superficial Inspections will require visual inspection of all bridge parts from the nearest available access points. Routine Superficial

Inspections do not require inspectors to access, or to walk along, the main cable. Any concerns noted during a routine superficial Inspection of the bridge parts above road deck level will prompt a Special Inspection that may involve inspectors walking along the main cable to investigate the concern. Routine Superficial Inspections should be planned to ensure that all external parts are visually inspected at three-monthly intervals for the initial years after construction.

Routine General Inspections should be Close Visual Inspections, undertaken at two yearly intervals by the inspection team walking along the main cable using mirrors to view the areas on the underside of the cables. The top hanger sockets and adjacent length of hanger should be viewed using mirrors with the lower sockets and lower length of hanger inspected from deck level. The intermediate sections of hangers should be viewed to identify any irregularity in the HDPE sheathing.

Principal Inspections are to be undertaken every six years and will require access to be provided via the cable access gantries. It is suggested that Principal Inspections be undertaken on the main cables on one side of the bridge at years 3, 9 and 15 and the other side at years 6, 12, 18 etc. Any particular concerns noted during such inspections of one cable could require a Special Inspection for similar issues on the opposite main cables.

Where Reliability Based Inspections are developed for particular aspects of the elements covered by this TP then the scope of the associated Routine and Principal Inspections should be developed to integrate and coordinate the inspection requirements.

The following timetable for the initial Routine General Inspections, Principal Inspections is suggested:

YEAR	EAST CABLE	WEST CABLE
1	Routine General	None
2	None	Routine General
3	Principal	None
4	None	Routine General
5	Routine General	None
6	None	Principal
7	Routine General	None
8	None	Routine General
9	Principal	None

The Routine Superficial Inspections shall be undertaken to each cable, initially at three monthly intervals, unless a Routine General Inspection or Principal Inspection is being undertaken. Following satisfactory inspection results at the initial Principal Inspection, this period may be amended to six-monthly.

When planning inspections, the Technical Manager should take account of the local environment to ensure that weather conditions do not prevent inspection or maintenance activities being undertaken safely and efficiently.

9. Reporting

Reporting shall be in accordance with TP 1.01

Reporting of Routine Inspections shall require the completion of the proforma included within the Technical Instructions.

10. Distribution and Filing

All reports under this procedure are to be prepared under the direction of the Discipline Manager. The Technical Manager is to be provided with copies of all associated reports to determine any further work required. The Technical Manager will either arrange for any follow up work to be undertaken or will seek authority to allow such follow up work to go ahead.

All associated reports, drawings, photographs etc are to be clearly referenced before being stored in the main archive.

11. Procedures for undertaking potential repairs

The inspections covered by this Procedure may identify the need for a range of repairs or remedial work. The following is a non-exhaustive list of potential remedial work for which method statements should be prepared and incorporated as an Appendix to this document:

- Patch repairs of main cable neoprene wrapping.
- Patch repairs of hanger cable HPDE sheathing.
- Repair work to cable clamp sealant.
- Patch painting repairs.
- Repair of hand strand rope corrosion protection system.

Team Leaders should ensure that the equipment and materials associated with the above are either in stock are or available at reasonable notice.

12. Bridge component sheets

Component Sheets have been developed for each of the elements covered by this Technical Procedure. These sheets are intended to provide a summary of the pertinent issues associated with individual elements or with groups of elements. The sheets developed with this TP are included as an Appendix to the Inspection and Maintenance Manual and are summarised below:

Bridge Element	Component Sheet
Main cable and wrapping membrane.	TP 3.02 .1.A
Cable clamps; castings, bolts and seals.	TP 3.02 .1.B
Hangers, sheaths, sockets and connections.	TP 3.02 .1.C
Handstrand ropes, posts and anchorages.	TP 3.02 .1.D
Tower Saddles.	TP 3.02 .1.E
Splay Saddles in anchor blocks.	TP 3.02 .2.A
Main cable anchorage components.	TP 3.02 .2.B
Secondary Steelwork in anchor blocks.	TP 3.02 .2.C

Appendix 1 – see section 5 above.

Appendix 2 – see Section 12 above

Appendix 5.10.B - Technical Procedure for inspection and maintenance of Steel Bridge Structures - Towers and Deck Boxes

Technical Procedure No. 3.01: Element 1.2.1. (P-SV-T4) (Towers) and Element 1.2.3. (P-SV-I3)(Deck).

TECHNICAL PROCEDURE FOR INSPECTION AND MAINTENANCE OF STEEL BRIDGE STRUCTURES – TOWERS AND DECK BOXES DRAFT

1. Purpose

This Technical Procedure describes the inspection and maintenance activities that are required for the steel box girder structures of the Messina Strait Bridge. These box girder elements include the steel bridge deck boxes together with the tower legs and crossbeams. The procedure is provided to set out the inspection and maintenance activities necessary to ensure that these elements of the bridge are maintained such that their function is assured, throughout the bridge design life, without the need for unplanned corrective maintenance works.

This procedure sets out the requirements for the following categories of Inspection:

a) Routine Inspections
b) Principal Inspections
c) Special Inspections

The procedure covers those bridge parts listed under Section 2 below. However, the following parts will be accessed during aspects of the inspections and consideration should be given to inspecting such parts concurrently:

- Access stairs and platforms in the bridge deck and towers.
- Access doors and manholes.
- Internal services.
- Service lanes.
- Wind Screens.

The Technical Instructions will be developed to include visual inspection of these secondary elements.

2. Validity of the Technical Procedure

This procedure relates to the internal and external surfaces of the following structural steelwork elements of the primary structure of the bridge:

Element 1.2.1.1 (P-SV-T4-TS)	Tower Sicily
Element 1.2.1.2 (P-SV-T4-TC)	Tower Calabria
Element 1.2.3.1 (P-SV-I3-CF)	Steel Girder, Railway
Element 1.2.3.2 (P-SV-I3-??)	Steel Girder, Roadway Direction Sicily
Element 1.2.3.3 (P-SV-I3-??)	Steel Girder, Roadway Direction Calabria
Element 1.2.3.4 (P-SV-I3-TP)	Main Cross Girders

3. Reference Procedures and Instructions

Prior to commencing work on site, personnel are to ensure that they are familiar with all the associated manuals and procedures that have been developed for safe and effective working on the structure. Not all such documents will be directly relevant to each of the individual tasks but all staff should be familiar with the overall philosophy and background to the inspection and maintenance procedures.

The following documents should therefore be reviewed prior to undertaking the inspections covered by this Technical Procedure:

The Operation and Emergency Manual.

The Inspection and Maintenance Manual.

TPXX Health and safety, including working in confined spaces, PPE. Weather restrictions on access.

TPXX Working procedures for the bridge, e.g. radio operation, site vehicles, access routes.

TPXX Use of access equipment, e.g. gantries, lifts.

TP1.01 Principal Inspections (and Definitions of defect types, extent and severity ratings).

4. General Description of the System

The parts covered by this TP and the associated TIs are the fabricated steelwork box girder elements. These sections are made up from steel plates that have been shaped and stiffened, fabricated into the required unit sizes, transported to site and erected. The stiffeners are generally flat sections for the tower walls and trough stiffeners for the bridge deck boxes; additional longitudinal L-beams are provided under the lines of the rails in the railway section. Site connections are generally welded for the box girder deck sections and bolted for the tower box sections; although these units also include site welds.

Corrosion protection to external surfaces is provided by a paint system or by a proprietary waterproofing system. Internal steel surfaces are protected from corrosion by a paint system and also by a dehumidification system.

The parts covered by this TP are substantial elements with a significant amount of repetition in the fabricated units. The inspection of these units will also therefore be extremely repetitive. For this reason the application of Reliability Based Inspection (RBI) principles is recommended. RBI covers systems and elements with a predictable failure pattern, where the degradation rate can be measured and is particularly beneficial for multiple repetitive elements.

Under RBI, Special Inspections are undertaken on a number of representative areas where close visual inspections and specific testing and measurements can be carried out to produce a condition indicator. The other areas are inspected less thoroughly, e.g. visual inspection, sufficient to identify any large deviations from the standard of the selected reference areas. One example of RBI would be the paint system applied to the external surfaces of the bridge deck boxes and the bridge towers; it is presently envisaged that the top coat should be replaced after twenty years. If a number of reference areas could be identified and subjected to a Special Inspection every four years, then in time the rate of degradation could be assessed and an accurate estimate made of the projected optimum time for the top coat to be renewed.

The application of RBI can also justify an increase in the periods between Principle Inspections for particular items.

5. Historical Reference Documents

Prior to undertaking the inspections covered by the Technical Procedure, managers and inspection staff should have access to and be familiar with the following:

- Previous inspection records of the associated parts.
- Construction records, data sheets etc for the associated products and materials.
- Associated sections of the bridge construction stage specifications.
- Records of changes to or clarifications of the specification during construction.
- Records of any associated non-conformances recorded during construction.
- Construction as-built drawings, reports, testing, certification and acceptance records.

These records will need to be developed and maintained during the construction phase. These should be compiled as an Appendix to this Procedure. See Appendix 1.

6. Specialist equipment

When planning the inspections covered by the Technical Procedure, the following specialist equipment may be required. The Technical Manager is to ensure that the necessary equipment is available and, if necessary, calibrated for the period of the inspection. The associated Technical Instructions should also be reviewed to ensure all other necessary equipment is identified.

- Tower, Crossbeam and Under deck access gantries
- Paint thickness gauge
- Weld Gauge
- Magnetic Particle Inspection (MPI) equipment
- Ultrasonic weld testing (UT) equipment
- Others

7. Responsibility

The Technical Manager is responsible for the maintenance of this Technical Procedure and the associated Technical Instructions. The Technical Manager has the overall responsibility for ensuring that this procedure is followed and incorporated into the Activity Plan.

The relevant Inspection and Maintenance Team Leader has responsibility for planning, activating and managing the activities in accordance with the Activity Plan. After completion of the activity the Team Leader ensures that the necessary report is prepared in line with the particular instruction.

The Technical Manager will review all reports and determine any follow up action required. The reports will also be used to assess the rate of wear or deterioration of the bridge elements to enable effective planning of repair or replacement work. This will allow accurate cost forecasting and ensure that specialist spare parts or equipment can be sourced in good time.

The Team Leader has responsibility for ensuring that all persons undertaking inspection and maintenance work are familiar with the operational and safety procedures associated with their tasks and that the necessary notices and permissions have been issued.

8. Description of Activities

The following Technical Instructions are to be developed for the inspection and maintenance of the bridge parts associated with this Technical Procedure:

- TI 3.01.1 Tower and cross beams Internal surfaces
- TI 3.01.2 Tower and cross beams External surfaces
- TI 3.01.3 Deck Box Girder Internal surfaces
- TI 3.01.4 Deck Box Girder External surfaces
-

The bridge parts have been grouped into these Technical Instructions to facilitate effective inspection of the components making up the steel box girder sections of the bridge; principally the bridge decks and the towers. These Technical Instructions may be reviewed and revised to allow alternative bridge element groupings if required by the Technical Manager.

Routine General Inspections should be Visual Inspections (V.I.), undertaken at two yearly intervals by the inspection team entering each box girder section to view the areas. Inspectors shall be particularly vigilant when inspecting the deck welds beneath the traffic lanes, beneath the lines of the rails in the railway section and other areas of concern noted during construction

Principal Inspections are to be Close Visual Inspections (C.V.I.) undertaken so that all elements are covered over any six year period. It is suggested that Principal Inspections are undertaken to various parts similar to that set out in the table below. Any particular concerns noted during such inspections of one area could require a Special Inspection to determine whether similar issues exist on similar areas in other box girder elements. Subsequent Principal and Routine Inspections may also need to take account of any such concerns so as to promptly identify any developing trends.

Where Reliability Based Inspections are developed for particular aspects of the elements covered by this TP, e.g. external painted surfaces, then the scope of the associated Routine and Principal Inspections should be developed to integrate and coordinate the particular inspection requirements of the RBI programme.

To meet the requirement for general inspections to be undertaken every two years and for all parts to have a Principal Inspection every six years it is suggested that these inspections are spread out over a six year cycle. The following timetable suggests a 6-year rolling programme for Routine General Inspections and Principal Inspections for the bridge deck structure with RBI Special Inspections included at 6yearly intervals:

YEAR	Roadway Sicily	Railway Girder	Roadway Calabria	Cross Girders	RBI Special Inspections
1	½ Routine	½ Principal	½ Routine	½ Routine	
2	½ Routine	½ Principal	½ Routine	½ Routine	
3	½ Principal	½ Routine	½ Routine	¼ PI and ¼ Routine	
4	½ Principal	½ Routine	½ Routine	¼ PI and ¼ Routine	
5	½ Routine	½ Routine	½ Principal	¼ PI and ¼ Routine	
6	½ Routine	½ Routine	½ Principal	¼ PI and ¼ Routine	Selected Paint Areas (external)

A similar arrangement may be developed for Routine and Principal Inspections of the Towers and Crossbeams.

When planning inspections, the Technical Manager should take account of the local environment to ensure that weather conditions do not prevent inspection or maintenance activities being undertaken safely and efficiently, e.g. temperature inside the box girder elements.

9. Reporting

Reporting of Principal Inspections shall be in accordance with TP 1.01.

Reporting of Routine Inspections shall require the completion of the proforma included within the Technical Instructions.

10. Distribution and Filing

All reports under this procedure are to be prepared under the direction of the Discipline Manager. The Technical Manager is to be provided with copies of all associated reports to determine any further work required. The Technical Manager will either arrange for any follow up work to be undertaken or will seek authority to allow such follow up work to go ahead.

All associated reports, drawings, photographs etc are to be clearly referenced before being stored in the main archive.

11. Procedures for undertaking potential repairs

The inspections covered by this Procedure may identify the need for a range of repairs or remedial work. The following is a non-exhaustive list of potential remedial work for which method statements should be prepared and incorporated as an Appendix to this document:

- <u>Patch painting repairs.</u>
- <u>Weld repairs.</u>

Team Leaders should ensure that the equipment and materials associated with the above are either in stock are or available at reasonable notice.

12. Bridge component sheets

Component Sheets have been developed for each of the elements covered by this Technical Procedure. These sheets are intended to provide a summary of the pertinent issues associated with individual elements or with groups of elements. The sheets developed with this TP are included as Appendix 3 and are summarised below:

Bridge Element	Component Sheet
Deck Girders – internal steel structure.	TP 3.01.3.A
Deck Girders – internal, secondary steel.	TP 3.01.3.B
Deck Girders – internal, access manholes.	TP 3.01.3.C
Deck Girders – external surfaces and platforms.	TP 3.01.4.A
Deck Secondary structures – wind screens.	TP 3.01.4.B
Deck Secondary structures – Service Lane.	TP 3.01.4.C

Appendix 1 – see section 5 above.

Appendix 2 – see Section 11 above

Appendix 3- see Section 12 above

Appendix 5.10.C - Technical Procedure for Principal Inspection

Technical Procedure No. 1.01: Principal Inspection.

Technical Procedure for Principal Inspection.

1. General

This Technical Procedure describes the procedure for *Principal Inspection* of structural elements and structures.

The inspections are carried out with the purpose:

- to monitor that the safety level of the structures of Messina Strait Bridge is maintained without significant adverse influence on the traffic flow
- to detect defects in due time so it is possible to select the optimal repair strategy (time and method to repair) for the different structural elements in order to avoid the need for unplanned corrective maintenance
- to provide a regular condition rate of all the various structural elements
- to provide basis for long term budgets for repair and replacement of elements with limited life time
- to initiate special inspections where necessary to determine the cause/extent of defects and to assess whether they need to be rectified or monitored.

The Principal Inspection Reports are also used to give important input for time and cost management.

The monitoring is performed by regular principal inspections by systematic close visual inspections of all accessible parts of the structure and - when required - using simple tools or instruments to investigate the defects on site during the inspection.

The purpose of this Technical Procedure is to ensure that anybody who is required to carry out principal inspections at the Messina Strait Bridge has at all times been appropriately instructed on how such inspections are to be undertaken and how such inspections are to be recorded and reported:

The related Technical Instructions are element-oriented documents describing in detail the activities that shall be carried out at the principal inspections.

2. Scope of Validity

This Technical Procedure contains information on Principal Inspections of structures to the inspection and maintenance staff and to other involved parties.

The procedure covers all structural elements as described in section 4 of theI&M Manual of the Messina Strait Bridge.

3. Reference Procedures and Instructions

Prior to commencing work on site, personnel are to ensure that they are familiar with all the associated manuals and procedures that have been developed for safe and effective working on the structure. Not all such documents will be directly relevant to each of the individual tasks but all staff should be familiar with the overall philosophy and background to the inspection and maintenance procedures.

The following documents should therefore be reviewed prior to undertaking the inspections covered by this Technical Procedure:

The Operation and Emergency Manual.

The Inspection and Maintenance Manual.

TPXX Health and safety, including working in confined spaces, PPE. Weather restrictions on access.

TPXX Working procedures for the bridge, e.g. radio operation, site vehicles, access routes.

TPXX Use of access equipment, e.g. gantries, lifts.

TI 1.01.1 Instruction on Reporting

4. Responsibility

The Technical Manager is responsible for the maintenance of this Technical Procedure and the associated Technical Instructions. The Technical Manager has the overall responsibility for ensuring that this procedure is followed.

The relevant Inspection and Maintenance Team Leader has responsibility for planning, coordinating and managing the activities in accordance with the Inspection Programme. After completion of the activity the Team Leader ensures that the necessary report is prepared in line with the particular instruction.

The Technical Manager will review all reports and determine any follow up action required. The reports will also be used to assess the rate of wear or deterioration of the bridge elements to enable effective planning of repair or replacement work. This will allow accurate cost forecasting and ensure that specialist spare parts or equipment can be sourced in good time.

The Team Leader has responsibility for ensuring that all persons undertaking inspection and maintenance work are appropriately trained and familiar with the operational and safety procedures associated with their tasks and that the necessary notices and permissions have been issued.

5. Activities

5.1 General

These purposes of the principal inspections are fulfilled by:

- Recording the type, extent and severity of any significant defect
- Recording the general condition of the structural main elements (at level 5 of the hierarchy) and the defects on each of its sub-elements; the condition is recorded by means of a rate from 0 to 5 See 5.3.4
- Reporting the need for any special inspections
- Reporting the need for any maintenance works – other than preventive maintenance works - to be carried out
- Determining the appropriate year for the next principal inspection, but the frequency of principal inspections should not exceed 6 years without careful consideration. Normally the frequency will either be based on performed Failure Mode, Effect and Criticality Analysis (FMECA) or based on engineering judgement depending on the condition of the element, the traffic load on the element and the expected rate of damage development.

The condition of the bridge elements and the repair works are related to the hierarchy elements at level 5.

This procedure and the related general Technical Instructions set up the general instruction on how to carry out the inspections. The specific Technical Inspections for each particular structural part further instruct on which particular type of defects the inspector shall be aware of at the individual elements. However, the inspector should use his professional knowledge also to inspect for other types of defects than those specifically indicated in the procedure and related instructions.

The Messina Strait Bridge is a large structure consisting of a number of major elements many of which consist of a large number of identical parts. Principal inspection, with close visual inspection of each of these parts may be considered as unnecessarily excessive. An alternative would be to concentrate inspections on areas where defects are more likely to develop with random inspections of other parts. Whenever the condition mark, ref. sect. 5.3.4 exceeds mark 1 the size of the random parts may be increased. However, all parts would continue to receive Routine Inspections and defects noted by these inspections may also trigger an increase in the Principal Inspection of other parts.

5.2 Principal Inspection Planning

5.2.1 Preparatory works

See the specific Technical Instruction for the structural element to inspect.

5.2.2 Review of Inventory and Inspection Reports

To make himself familiar with the particular aspects concerning the elements the inspector shall review the following documents:

- I&M Manual section 4 in particular to notice the element number system and the location codes to apply for the inspections
- This procedure and the related general technical procedures and technical instructions
- The particular inspection instructions valid for elements to inspect
- The technical instruction for Principal Inspection Reporting
- The last Maintenance Inspection Report covering the actual element
- The last Principal Inspection Records covering the actual elements (inclusive of photos)

In the inventory numbers and location codes have applied for all elements. The numbers and codes have been detailed to such a degree that no further detailing should be applied. These codes are mandatory for the records.

The inspector should browse the last Principal Inspection Report and other Inspection Reports to be aware of any previously reported significant defects, whether they have been repaired and whether the defect locations can be inspected by the planned access facilities.

For some of the principal inspections this review of earlier reports should be executed very thoroughly and carefully to ensure that cost effective use is made of the access equipment and the personnel involved. Such Inspections will include all exterior surfaces of the superstructure and particularly all areas of the suspension system.

5.3 Carrying out Principal Inspection

5.3.1 Overall inspection/orientation

The inspector should at first make himself familiar with the actual conditions for the inspection. He should also check the location codes to apply by finding reference locations as described in section 4 of the I&M Manual and appended drawings.

The required data information described in the Technical Instruction TI 1.01.1, Instruction on Reporting, should be recorded in the BMS Database**.** The reported data are divided into three sections:

- basis for inspection to be reported before the inspection
- reporting of data on site for factual registration of all individual defects
- reporting of data that should be used to summarise the defects on the record and supplement with all recommendations for repair or for Special Inspections. . This major part of data shown in this scheme may be reported after having concluded the inspection.

Overall photos each structure/element to inspect should be recorded in the BMS Database.

The dates and weather conditions at the time of inspection should be recorded too.

5.3.2 Element inspections (defect registration)

At the inspections only significant defects should be recorded in the field "Defect description". This means defects that already at the time of inspection or due to the expected development are evaluated to:

- influence on the structural safety or durability
- influence on the driving comfort
- influence on the safety for third persons

Defects, that earlier have been recorded, should be traced to:

- follow up and check if repair works have been carried out according to recommendations in the inspection reports
- if the defects have developed since the last inspection

Only defects, which may be rectified by either corrective maintenance or repair works, should be recorded. Below type of defects should e.g. not be recorded:

- Defects, which may be remedied by preventive maintenance
- Fine cracks in concrete structures except for cracks at the anchoring zones of the main cables
- Dry deposits on interior concrete faces caused by earlier water ingress

To ease the inspection a number of Technical Instructions for specific bridge parts have been prepared.

To assist the inspector on the phrasing of the report a list with defect types has been prepared, see section 5.3.3. Furthermore in section 5.3.4 guidelines for condition rating of specific defect types are given.

Each defect should be recorded by:

- the element number inspected
- a defect description (including evaluation of the cause of the defect)
- the location of the defect applying location codes of the inventory
- the extent of the defect
- the severity of the defect
- photos – also to ease evaluation of any future development

5.3.3 Classification of defects

The types of defects to be particularly looked for during inspections are to be categorised as follows:

Defect Type B – Bearings and Expansion Joints	
Description	**Code**
Debris Ingress	BDI
Loss of surface coating	BLC
Change of clearance	BCL

Defect Type B – Bearings and Expansion Joints	
Elastomer Defect	BED
Noise	BNS
Scuffing/Abrasion	BSC
Wear	BWR

Defect Type C – Corrosion	
Description	**Code**
Surface rusting	CSU
Rust staining	CST
Corrosion damage - pitting	CDP
Corrosion damage – spalling, bursting	CDA
Zinc Oxide formation	CZO

Defect Type D – Damage and Deterioration	
Description	**Code**
Bolt Failure	DBF
Bolt Loose	DBL
Deformation. - Buckling and twisting	DDE
Gouge, scar or indentation	DGS
Cracking of Weld/Steel	DCW
Defective Cable Wrapping/Sheathing	DEF
Defective Sealant	DSE
Defective Paint	DPT
Wire Fracture	DWF
Wire out of lay	DWO
Socket draw	DSD
Leak / Water Ingress	DWI

Defect Type K – Concrete Parts	
Description	**Code**
Cracking	KCR
Spalling	KSP
Exposed Reinforcement	KRE
Lack of cover	KCV
Efflorescence/Staining	KEF
Chloride Ingress and Carbonation	KCC
Water Ingress	KWI

Defect Type S - Surfacing	
Description	**Code**
Cracked	SCR

Defect Type S - Surfacing	
Lifting	SLF
Missing	SMI
Movement or Creep	SMO
Tracking or Rutting	STR
Reduced Friction	SRF
Joint Deterioration	SJT
Chemical Damage, e.g. Diesel spill	SCD
Mechanical damage - Scrape or Indentation	SMD
Fire or heat damage	SFR
Loss of ride quality	SRQ

5.3.4 Condition rates

The condition of the bridge is evaluated for each of the structural elements on level 5.

The evaluation and the condition rate of each element must be accomplished under consideration of the degree of distress or deterioration of the element and its ability to fulfil its function, i.e. the capability to meet the actual strain or load *at the date of inspection.* Moreover the condition rate shall reflect whether the defect already has caused any consequences on the functionality of any adjoining members.

The condition rate should not be influenced by the lack of minor preventive maintenance. However, if the lack of proper maintenance or cleaning has lead to damage to the structure this may influence the condition rate.

The condition rate is a figure from 0 to 5, according to the following guidelines:

Rate 0 – This provides a record that an area has been inspected and that, at the time of the inspection, there was no evidence of a defect.

Rate 1 – This provides a record that a minor defect has been noted but the inspector considers there is no need for a repair to be instigated. This may, for example, be a record of some minor deformation of a stiffener or some minor paint damage. Undertaking a repair may not be necessary or justified. However, if work of a similar nature was to be undertaken close by, then consideration could be given to addressing Rate 1 items.

Rate 2 – This reports the discovery of a defect which, in the opinion of the inspector, is something that should be addressed within about six months. The repair is not urgent but if it is not addressed then further deterioration will occur and the cost of repair will increase.

Rate 3 – Major defects are reported by an Inspector when he considers that if a repair is not carried out promptly it will result in an increased risk to safety, loss of function of the defective, or an adjacent, element or will result in the cost of repair rising rapidly.

Rate 4 – Such defects are reported when the Inspector is confused or alarmed by the nature or the cause of the defect or where he considers that further or specialist assistance (Special Inspection) is required to fully investigate the concern. Rate 4 defects may include defects reported as Rate 3 if the Inspector considers that urgent repair and further investigation are both necessary.

Rate 5 - This records that an area was not able to be inspected at the time that the Principal Inspection was undertaken, e.g. due to the element being inaccessible. As such a Special Inspection (Type A) will be required to confirm the condition of the element.

Briefly the condition rates are summarized in the following table:

Table 5.3.1 Condition rating of defect severity

Defect Severity	
Description	**Condition rate**
Area inspected – no defect noted.	0
Minor Defect - no necessity to instigate repair	1
Significant Defect - repair needed within 6 months	2
Major Defect - requires urgent repair	3
Special Case – requires urgent investigation and action	4
Unknown (Inaccessible elements)	5

Special Inspections or reducing the principal inspection interval should also be considered when giving an element condition rate 2 or higher to determine the defect cause or defect extent to select repair strategies. When choosing repair methods that remove the cause of a defect the defects should not redevelop.

The condition rate 3 should be avoided by initiating necessary inspections and identifying maintenance/repair works in good time.

It is beyond the scope of this procedure to describe in detail how to evaluate damaged structures. It is assumed that the inspector is capable of assessing the degree of distress/deterioration and to determine which parts of the bridge need close investigation. The following sections give rough general guidelines that may be used for the various defect types:

General guidelines.
If you encounter signs of inadequate carrying capacity (some of the above mentioned or others), always ask for special inspection type C, see sect. 5.6 in I&M Manual.

Road surfacing
Single type of damages even though they may be major cracks or potholes should not be paid the same attention as repetitive types of minor damages. The single types may be rectified under preventive maintenance.

- Any type of damage which indicate material disintegration or loss of stability should give condition rate 2 or higher

Reinforced concrete structures:
The influence of cracks on the bearing capacity may be harmless at the time of inspection but some cracks may initiate corrosion that later may be critical. Fine cracks in reinforced structures may be harmless unless the structure is exposed to very aggressive environment, e.g. positioned in the splash zone of saline water. Fine cracks in pre-stressed structures are more critical.

- If all the crack widths are less than 0.25 mm it may be assumed that the stresses are not too high, and no further action is to be taken. The condition rate will be 1 or 2. Make a record of the cracks in the field “Defect description” so the next inspector will know that the cracks are not new.
- If the crack width is between 0.25 and 0.5 mm the stresses may be high but they are not assumed to be dangerous. If it is possible, record the crack width, crack length and crack distance in shear and bending zones in the field “Defect description”. The condition rate will normally be 2.
- If the crack width is larger than 0.5 mm it indicates that the stresses are high and that there may be a problem regarding the load carrying capacity. Record the dimensions of the girder, the crack width, crack length and crack distance in the shear and bending zones in the field “Defect description”. Note that the width of the bending cracks is measured at the main reinforcement even if the crack width may be larger at a greater distance from the edge of the beam.) The condition rate will be 3 or more.

S-shaped” cracks (shear cracks) e.g. near the centre of the span or - on continuous girders - near the supports indicate very high stresses in the bending as well as the shear reinforcement. In this case, always ask for a special inspection. (See Figure 5-1).

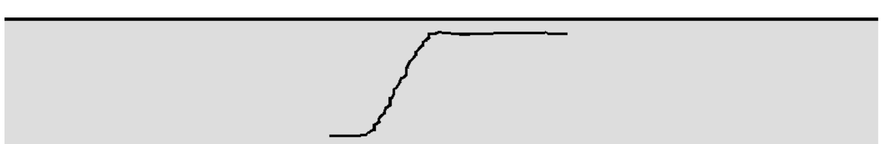


Figure 5-1 “S-shaped” cracks in girders.

- If the crack pattern is different from the “classical” picture and you are not sure that the cracks are harmless, ask for a special inspection.
- Not only main girders but also diaphragms may have serious bending and/or shear cracks indicating overload, and need for special inspections.
- Cracks or spalling at the joint between main girders and diaphragms may indicate anchorage problems due to an insufficient or erroneously placed reinforcement.
- Eccentricity between piles and columns may induce bending moments in columns (and piles). Normally the structures are not designed to resist this.
- Inclined coarse cracks crossing the whole cross section of columns/piles may indicate a compression failure (in particular if there is a displacement between the two parts on either side of the crack).

Pre-stressed concrete structures:
Defects indicating corrosion at the pre-stressing cables should be given condition rate 2 or higher and a special inspection type B should be requested

- Damages indicating medium cracks in the bending zones should be given condition rate 2, coarse cracks should be given 3 and a special inspections (type B or C) should be requested

Steel structures:
It is essential for the function of steel structures that the members (in particular members in compression) are not deformed, as compression forces in connection with deformation produce unintended bending moments and a risk of stability failure

- Even minor unintended eccentricities may induce significant bending moments in secondary members and subsequent buckling.

Guidelines for condition rating of specific defect types:
The assessment of the condition rate is based on the risk of loss of structural integrity for each category of defect. When carrying out an inspection, the severity is to be recorded at the appropriate rating.

The general rating of the condition is as described in the table above.

Type B defects - Bearings and Expansion Joints:

Defect Severity	
Description	**Condition rate**
Area inspected – no significant defect.	0
Perceptible defects but no apparent effect on performance	1

Defect Severity	
Description	**Condition rate**
Defectiveness affecting performance and causing preventive perceptive noise.	2
Seized join/bearing effectively preventing intended movement and/or very loud noise requiring immediate investigation for rating 1 & 2.	3
Special Case – requires urgent investigation and action	4

Type C defects - Corrosion:

Defect Severity	
Description	**Condition rate**
No significant defect	0
Surface discoloration only with no build-up of corrosion products or loss of section.	1
Build up of corrosion products and some loss of section by not more than 3%	2
Heavy corrosion and/or loss of material or other damage. Section of plate or capacity of element reduced by more than 3%.	3
Special Case – requires urgent investigation and action	4

Type D defects - Damage and Deterioration

Defect Severity	
Description	**Condition rate**
Area inspected – no significant defect.	0
Perceptible defects/early deterioration of seals.	1

Defect Severity	
Description	**Condition rate**
For Defect Type DDE and DGS: Maximum measured departure from intent is less than 10% of adjacent section/plate and other minor defects.	
For Defect Type DBF and DBL: Up to 10% of bolts in any connection. For type DDE: As above (for condition rate 1) but more than 10 % of adjacent plate thickness or section size. For type DGS: See Condition Rate 4 below. For type DCW: 5% - 10% of weld length or individual defects over 50 mm whichever is the less - monitor to be instituted until repaired. For type DPT: Weathering of top coat with some local failure down to undercoat or to expose galvanizing on areas larger than 0,05m^2. For type DWO: Any wires out of lay.	2
For Defect Type DBF and DBL: More than 10% of bolts in any connection. For type DDE: As above (for condition rate 1) but greater than twice the plate thickness. For type DGS: See Condition Rate 4 below. For type DCW: More than 10% of weld length and/or individual weld failures over 100 mm long whichever is the less. For type DEF and DSE: Any leakage against dehumidified area	3

Defect Severity	
Description	**Condition rate**
For type DPT: Failure of coating system down to bare metal including loss of galvanising. For type DWF: Any wire fractures. For type DSD: More than 10 mm.	
For defect Type DGS: Any gouge, scar or indentation deeper than on the surface, requires a further investigation by a specialist to evaluate the defect, make a determination of the condition rate and a description of the defect in order to make it possible for the principal inspector to evaluate any further deterioration of the defect at the next principal inspection. If there is no development the principal inspector can give the defect the previous condition rate without any further consultation. Special Case – requires urgent investigation and action	4

Type K defects - Concrete Parts:

Defect Severity	
Description	**Condition rate**
Area inspected – no detectable defect.	0
Perceptible defects with negligible effect on structural performance.	1
Potential effect on structural performance, traffic and/or long term effect on structural life including cracks > 0.25 mm in width and loss of concrete cover to reinforcement.	2
Sufficient to influence structural integrity.	3
Special Case – requires urgent investigation and action	4

Defect Severity	
Description	**Condition rate**

Type S defects - Surfacing:

Defect Severity	
Description	**Condition rate**
Area inspected – no detectable defect.	0
Perceptible defects but no reduction in ride quality.	1
Significant defect with perceptible reduction in ride quality and/or adhesion value over area greater than 10 m long.	2
Obvious immediate danger to traffic and/or structure requiring immediate diversion of traffic.	3
Special Case – requires urgent investigation and action	4

5.3.5 Extent of Defects

In the previous section, 5.3.4, the Condition Rating or severity of each defect was established so as to allow the more severe defects to be highlighted in any report. This section, 5.3.5, sets out the way in which the extent of each defect is to be reported and recorded so as to enable easy comparison with previous inspections thus allowing the deterioration of any part to be measured over a period of time.

Type B defects - Bearings and Expansion Joints

Type	**Description of extent**
BDI	Give dimensions of area affected
BLC	Give dimensions of area affected
BCL	Give measured clearance
BED	Give dimensions of area affected

Type	Description of extent
BNS	Describe noise source and intensity
BSC	Give dimensions of area affected
BWR	Give dimensions of area affected

Type C defects – Corrosion

Type	Description of extent
CSU CST CDP CDA CZO	Extent N - No significant defect. Extent S - Slight, not more than 5% of area affected. Extent M - Moderate - 5 to 20% affected. Extent E - Extensive - more than 20% affected Note: Dimensions of area inspected to be noted where percentages recorded.

Type D defects - Damage and Deterioration

Code	Description of extent
DBF	Record number and location of bolts affected
DBL	Record number and location of bolts affected
DDE	Give dimensions of defect in millimetres
DGS	Give dimensions of defect in millimetres
DCW	Record location, length and nature of each crack
DEF	Describe extent and location of defect
DSE	Describe extent and location of defect
DPT	As for type C defects

Code	Description of extent
DWF	Record numbers and location of observed or suspected fractures
DWO	Record numbers and location of wires out of lay
DSO	Record extent of draw
DWI	Describe extent

Type K defects - Concrete Parts

Code	Description of extent
KCR	Describe extent and nature
KSP	Plot extent and parameters from specified tests
KRE	Describe extent and nature
KEF	Describe extent and nature
KCC	Describe extent and nature
KWI	Describe extent and nature

Type S defects - Surfacing

Code	Description of extent
SCR	Describe orientation and whether failure is full depth to steel.
SLF	Describe extent and depth of failure.
SMI	Describe depth and dimensions of area affected.
SMO	Describe extent and dimensions of area affected.
STR	Describe which lane, depth and length affected.
SRF	Describe which lane and length affected.
SJT	Describe evidence/extent of water ingress.

Code	Description of extent
SCD	Describe dimensions of area affected.
SMD	Describe depth of damage and dimensions of area affected.
SRQ	Describe nature of deterioration.

5.3.6 Special Inspection

If the inspector is uncertain regarding the evaluation of the elements, the causes and the extent of defects, or if he is not certain which repair strategy to recommend he should ask for a special inspection type B. This is reported by writing a “B” in the field, see Appendix 2 to TI 1.01.1, Instruction on Reporting. Otherwise the field is left blank.

Special Inspections should always be considered when giving an element the condition rate 2 or higher to prevent the defect to develop out of control.

Other types than above Special inspections type B of special inspections may also be requested, refer section 5.6 in the I&M Manual.

5.3.7 Photos

All photos should be recorded:

- each photo is recorded in the BMS database referenced to the defect it illustrates
- in field of the report in the database the number of photos taken regarding the actual element is entered.

A camera, which is able to print photo identification on the photos, should be used. The identification (normally the date (day number) and time (hour and minute)) is written in the principal inspection record form in the field and is later used for identifying the photos belonging to the specific inspection. The identification is only entered into the report if it is necessary to refer to a specific photo of an element (see “Defect description” sect. 5.3.2).

As help in identifying the photos from a specific element it may be useful always to start with a photo of the element identification no. written by chalk on the element according to the inventory. But do not include such photo in the report. A defect must be numbered with its "Defect Number" and then photographed.

Photos should be used to:

- Illustrate defects which may be difficult to describe

- Show development of defects between two inspections. In these cases the photographs of the defects should be recorded from the same positions

Whenever it may help to understand the defect the inspector should place a folding or a crack width gauge and/or a sign "up" next to the defect before taking the photograph.

For particular defects other kind of cameras should be used e.g. video cameras to illustrate vibration or movements phenomena.

6. Reporting

The principal inspection reports should be prepared by entering the data into the database as stated in the Technical Instruction:

- TI 1.01.1: Principal Inspection, Instruction on Reporting

The data to be entered are divided into three sections:

- the basis for inspection which should be entered before the inspection
- entering of data used on site for factual registration of all individual defects
- entering of data to summarise the defects on the record and supplement with all recommendations that may be entered after having concluded the inspection

Appendix 5.10.D - Technical Instruction for inspection of external Main Cable elements

Technical Procedure TP No. 3.02

Technical Instruction TI 3.02.1

1. (P) MESSINA STRAIT BRIDGE DRAFT

2. (SV) SUPERSTRUCTURE

2. (S7) SUSPENSION SYSTEM – (External Areas)

TECHNICAL INSTRUCTION FOR INSPECTION OF EXTERNAL MAIN CABLE ELEMENTS:

Primary Elements	**Description**
1.2.2.1. (P-SV-S7-CO)	Cable Clamps.
1.2.2.2. (P-SV-S7-SL)	Tower Saddles and shrouds.
1.2.2.3. (P-SV-S7-PE)	Hangers
1.2.2.4. (P-SV-S7-CA)	Main Cables – Exposed length between anchorages.
1.2.2.5. (P-SV-S7-??)	Handstrand Ropes, including support posts and anchors.

1. General

This Technical Instruction (TI) has been developed to provide the detail necessary for competent persons to carry out inspection and maintenance activities on the main cables along the length between the points where the cables enter the anchorages. This instruction includes for the Inspection and maintenance activities of the components attached to main cables, including the hanger cables.

Element 1.2.3.5 (Main suspension cables within anchorages, including splay saddles and anchors and the anchor steelwork assemblies) are covered under TI 3.02.2.

If any aspect of this document is not clear to the person tasked with undertaking these inspection and maintenance activities it is incumbent upon that person to seek the necessary clarification before commencing work.

The Technical Manager is responsible for ensuring that inspection and maintenance activities are undertaken as required by the associated Technical Procedures and Instructions. The Technical Manager shall assess the need for follow up actions based on the inspections.

Component Sheets are to be developed for each of the bridge parts covered by this procedure. These component sheets will provide additional reference information on these parts.

2. Preparatory Work

Prior to commencing work on site, personnel are to ensure that they are familiar with all associated procedures for working on the structure. These will include:

TPXX Health and safety, including working at height, PPE. Weather restrictions on access.

TPXX Working procedures for the bridge, e.g. radio operation, site vehicles, access routes.

TPXX Use of access equipment, e.g. gantries, lifts.

TP 1.01 Principal Inspections (and Definitions of defect types, extent and severity ratings).

Personnel must also ensure they are familiar with the following:

a) Results of previous inspections of the Bridge Parts.

b) Details of the construction drawings and specification for the parts being inspected.

c) Details of any associated non-conformance issues raised during construction.

d) Location reference systems for the Bridge Parts being inspected.

e) Use of any proforma developed for the inspections. (see Appendix 1).

f) Checking and operation of equipment, e.g. cameras, batteries, calibration certificates.

g) Details of any repair or replacement work undertaken to the parts being inspected since the previous inspection.

h) Bridge Component Sheets for the parts being inspected.

3. Access for inspection

Access to enable the required inspections to be undertaken can be achieved by a variety of means. For example, a Visual Inspection (VI) can be achieved by using binoculars, when necessary, from the deck level and from the tower tops. A Close Visual Inspection (CVI) can be undertaken by walking along the main cable using a mirror tied to a pole to view the underside areas. Where a more detailed, Principal Inspection (PI) is required, the main cable maintenance gantries should be used; these gantries include a hanger basket with hoist unit to allow close inspection of individual hangers.

4. Inspection Equipment

The following equipment should be available to the inspection team:

- Mandatory safety equipment.
- Site Radio.
- Clipboard.
- Inspection proforma and writing materials.
- 2m steel tape measure
- Camera with flash, zoom, date, video and audio capability.
- Binoculars.
- Cleaning Rags.
- Mirror on telescopic pole.
- Inspector's Aide Memoir with location reference details.
- Calibrated ultrasonic measuring equipment for measuring cable clamp bolt lengths - or
- Calibrated measuring gauge for measuring cable clamp bolt lengths.

Not all the above equipment will be required for all inspections. When working above road level all equipment must be securely fastened to the inspector or tied to the structure at all times.

5. Categories of Inspections

Routine Inspections, Principal Inspections and Special Inspections will all be required at various times. Specific requirements for each are given below:

5.1 Routine Inspections

Routine Inspections are those inspections which are undertaken with a predefined scope and frequency. For the components covered by this Technical Instruction a Routine Superficial Inspection will be required, for the initial period of operation, at three-monthly intervals. This inspection will require all elements to be visually inspected from points of readily available access, i.e. from deck level and from the tower tops. Binoculars will be required for many areas although closer visual inspections will be possible to some parts, e.g. the lower parts of each of the hangers and the main cable elements at the centre of the main span and the abutments.

A Routine General Inspection is to be undertaken a two yearly intervals. This inspection is to be undertaken by the inspectors walking along the length of the main cable using a mirror to view the underside areas. It is suggested that the first such inspection is carried out to the main cables on one side of the bridge after one year then alternating between each side of the bridge on a yearly cycle. The Routine General Inspections should be coordinated with the Principal Inspection requirement set out below.

The inspection team will report to the Technical Manager on any condition that may warrant further investigation via a special Inspection.

5.2 Principal Inspections

A Principal Inspection is a thorough inspection carried out by experienced Inspectors and undertaken within touching distance of the element being inspected. For the components covered by this Technical Instruction it will be necessary for the main cable gantries to be available to the inspection team. Concerns noted during the inspection that would rely upon the use of these gantries for subsequent Special Inspections should be advised to the Technical Manager promptly so that best use can be made of the access gantries.

A Principal Inspection is required every six years. It is suggested that the first such inspection is carried out to the main cables on one side of the bridge after three years then alternating between each side of the bridge on a three yearly cycle. In years when a Principal Inspection is carried out the annual Routine General Inspection may be omitted. The inspection team will report to the Technical Manager on any condition that may warrant further investigation via a special Inspection.

5.3 Special Inspections

Special inspections are all inspections which are not routine and will generally arise from defects or anomalies found during either Routine or Principal Inspections or arising from accidental damage. Special Inspections may also be required after specified extreme weather conditions but these have not been established for the bridge parts covered by the Technical Instruction.

Special Inspections arising from the findings of a Routine Inspection may be able to be initially investigated by inspectors walking along the main cable to the area of concern to allow a close or detailed visual inspection to be carried out, using mirrors if necessary. If such access is not suitable then further inspection may await the positioning of a main cable gantry.

Special Inspections arising from the findings of a Principal Inspection may make use of the access gantries if they are available and considered to be necessary. Otherwise access may be available by walking along the cable to the area of concern.

Current best practice advocates that main cables should be subject to a detailed intrusive inspection after a reasonable period of service life; for the Messina Bridge such an inspection is currently envisaged as being required after 30 years. Such an inspection would involve the removal of the neoprene wrapping over a number of selected sections between cable clamps. Wedges would be driven into the main cable to allow visual inspection of the internal as well as the external surfaces of the main cable to identify and to record the extent of deterioration. Based on the findings of such inspections, further such intrusive inspections can be programmed to establish an estimate of the rate of deterioration.

6. Scope of Inspections

The general scope of inspection is given below for the Bridge Parts covered by this TI. Notwithstanding the work covered by the scope, Inspectors are expected to be vigilant at all times and to report anything that appears to require attention or further investigation. This shall include aspects of structural behaviour such as unusual vibrations, noise or deflections; it shall also include any localised element of a bridge part that appears different from the normal condition for that part.

a. Bridge Element 1.2.2.4. (P-SV-S7-CA), Main suspension cables (for the length between anchorage entry points.)

This Bridge Part is expected to be covered by a neoprene wrapping with a friction surface applied to the crown to allow personnel to walk along the cables. Inspectors should report any unevenness, discolouration or damage to this wrapping and highlight any noted damage or indications of any deterioration to the main cable wires. The section of main cable at the top of the towers including the upper anchorages of the additional side span main cable strands are to be inspected as part of element 1.2.2.2. below. (Once the details of the arrangements at these locations have been established, this TI will be amended or a separate TI will be developed.)

b. Bridge Element 1.2.2.5. (P-SV-S7-??), Handstrand ropes (including anchorage points and associated support posts.)

The group of four handstrand ropes are used as supports and running rails for the main cable inspection gantries, use of the gantries will hasten erosion of the corrosion protection system on these ropes, this should be noted. The support posts are bolted to the cable clamps; these posts should be vertical. Any anomalies in the condition of the ropes or the posts should be recorded and the tightness of the clamps fixing the handstrand ropes to the posts should be checked and tightened if there are any signs of movement. The anchorage and terminations of each of the handstrand ropes should be inspected for any signs of wear or damage. Any signs of socket draw at the terminations should be measured and reported. Any deterioration to the corrosion protection systems should be recorded.

c. Bridge Element 1.2.2.1. (P-SV-S7-CO), Cable clamps (including bolts and seals.)

The cable clamp sections are tightly bolted together and rely upon friction to prevent them being pulled down the main cable by the forces in the hangers. There are several different types of clamps to suit particular locations on the main cables; many side span clamps do not carry hangers. Those in the central section of the main span incorporate spherical bearings whilst the number of bolts on the clamps varies throughout the bridge.

The cable clamps would be installed prior to the neoprene wrapping being applied to the main cables; as such the neoprene is not continuous at these clamps. To ensure that the dehumidified main cables are air and water tight, the cable clamps must be properly sealed at their joints, both longitudinal and circumferential.

The visual inspection should identify and record any evidence of movement of a cable clamp, any signs of distress of the bolts and also note any signs of damage to the sealant or the corrosion protection system of the clamps.

The clamping force of the cable clamps is applied via the cable clamp bolts, these are installed to a set force, determined by the accurate measurement of the length of the tensioned bolt. To ensure that the required clamping force is maintained at the correct level it will be necessary for these bolt lengths to be re-measured and their lengths compared with the construction records. Such measurements should be carefully taken at times when the main cable access gantry is in position on the cable. Any readings taken should be compared to the construction records to identify any change in length (hence change in tension) of the bolts. Measurement should be by Ultrasonic systems with 10% of clamps having all bolts measured during a Principal Inspection. If the tension has reduced by X% (c10% tbc) then all bolts on that clamp should be re-tensioned in the specified order and a check made on the bolts on adjacent clamps

Any deterioration to the corrosion protection systems should be recorded.

d. Bridge element 1.2.2.3. (P-SV-S7-PE), Hangers (including sockets, pins, bearings and attachments.)

All hanger cables are enclosed in HDPE sheaths with no maintenance envisaged for a period of at least 60 years. The spherical bearings that are included for the shortest hangers along the main span are also expected to have a life of at least 60 years; the spherical bearings are expected to be specified as 'maintenance free' although the facility to grease these bearings will also be specified; this may therefore produce a maintenance requirement in due course. Inspection of the hangers should seek to identify any abnormality in any hanger, e.g. socket draw, damage to, or movement of, the HDPE sheaths, localised discolouration of the sheaths or at the sockets. Any evidence or reports of hanger movements should also be recorded. Any deterioration to the corrosion protection systems should be recorded. In cases where dampers, bend limiters or spacers are fitted, these should be inspected to ensure they are correctly fitted and are functioning and that they are not causing damage to the HDPE sheathing.

e. Bridge element 1.2.2.2. (P-V-S7-SL), Tower Saddles and shrouds).

The main cables pass over the top of each tower leg via a saddle. The individual strands will open up from the uppermost cable clamp on either side of the saddle and be laid within cast steel channels. The additional side span strands will be anchored to the saddle. It is expected that the saddle will be enclosed by a shroud to facilitate dehumidification in this area and also to allow visual inspection of the main cable. The saddle is expected to be a combination of cast and fabricated steelwork. The shroud is also expected to be fabricated steelwork with access points to allow access to the saddle. Details are not yet determined to allow inspection to be described.

7. Recording of Inspections

It is essential that all defects and abnormalities noted during inspections are clearly recorded. Inspectors should ensure that the location, type, extent and severity of each defect is recorded and supported by a brief description and one or two supporting photographs. If the Inspector can clearly identify the cause of any reported defect then this should be included in the report. If the cause of any defect is unknown then this should be noted so that the need for a follow-on Special Inspection can be assessed.

It is also important that where an element has been inspected and no defect is found that this is also recorded.

Defects identified during previous inspections, but where no action was taken, should be re-inspected and given revised extent and severity ratings such that comparison can be made to earlier inspection records. The report should note the extent of deterioration.

All inspection reports shall be submitted to the Technical Manager and an assessment made of any required follow up activity.

Inspection staff are encouraged to include in their reports to the Technical Manager any comments on the effectiveness of this Technical Instruction and to suggest potential improvements.

8. Timing and Frequency of Inspections

The frequency of inspection of the above elements will vary over the lifetime of the bridge. Initially it is suggested that a visual inspection is undertaken from the roadway, using binoculars as appropriate, at three monthly intervals. The full length of one main cable pair should be inspected by close visual inspection every year, alternating each year with the other pair of main cables; this can be done by walking along the cable. If any areas of concern are noted from the close visual inspection then a more detailed Principal Inspection may be warranted using the cable access platforms.

Special Inspections may be required following extreme weather or following a reported incident.

9. Maintenance Activities

There are no scheduled regular maintenance requirements for the bridge parts covered by this Technical Instruction. All maintenance activities will be determined based on the findings of the above inspections and from any follow-on Special Inspections.

Anticipated maintenance will include patch repairs to the neoprene sheathing on the main cable and to the HDPE sheathing on the hangers, resealing of the longitudinal and circumferential seals on the cable clamps and minor paint repairs to the cable clamps, handstrand posts and hanger sockets. Use of the main cable access gantries will reduce the corrosion protection on the handstrand ropes. Procedures should be developed for each of these activities to ensure that repair methods and equipment will be available if needed.

10 Info to be obtained

The following issues should be considered and addressed or dismissed prior to the finalisation of this TI.

- In cases of severe weather are any associated inspections required to be undertaken? i.e. temperature, wind, lightning or seismic event.
- Will any Structural Health readings prompt any associated inspections?
- Will the dehumidification systems give an alert for damage to the integrity of the main cable sheathing? With approximate location??
- When will the tensions of the cable clamp bolts need to be checked?? A detailed procedure should be prepared giving both method plus acceptable and alarm thresholds. Need to ensure that construction records are available and bolt location reference system is unchanged. Is cable clamp design finalised – bolt length measurement difficult for inside bolts.

Appendix 1 – Inspection Proforma – see Section 2

A series of Inspection Proforma will be developed to cover all of the elements covered by this TI. The proforma will include clear identification of element and location, a summary of defect type, extent and severity together with reference to the associated photographs of the defects reported, e.g.

Cable clamp ref:

Cable Clamp Type:

Corrosion protection:	On clamp and all handstrand posts.
Signs of slippage:	Upper side and Lower ends
Condition of seals:	Circumferential – Upper and Lower on each cable.
	Lateral – On each side of each cable clamp.
Clamping bolts:	Observations and Measurements if made.
Handstrand Posts:	Fixing adequacy. Observations.

Main Cable between clamps Ref:

Main CableWrapping:	Observations and comments. Each Cable
Handstrand ropes:	Corrosion protection on each rope.
	Other observations and comments on each.

Dehumidification elements: (if applicable)

Attachments:	Observations and comments.

Hanger Ref: (if applicable)

Upper connection:	Observations and comments.
Top Socket:	Observations and comments.
HDPE Sheath:	Observations and comments.
Attachments: (if any)	Observations and comments.
Lower Socket:	Observations and comments.
Lower connection:	Observations and comments.

Appendix 5.10.E - Technical Instruction for inspection of main cable elements within the anchorage chambers

Technical Procedure TP No. 3.02

Technical Instruction TI 3.02.2

1. (P) MESSINA STRAIT BRIDGE DRAFT

2. (SV) SUPERSTRUCTURE

2. (S7) SUSPENSION SYSTEM – (WITHIN ANCHORAGES)

TECHNICAL INSTRUCTION FOR INSPECTION OF MAIN CABLE ELEMENTS WITHIN ANCHORAGE CHAMBERS:

Primary Elements	**Description**
1.2.2.2.1.	Splay Saddles
1.2.2.4.1.1-4.2.	Main Cables inside Anchor Blocks.
1.2.2.4.1.1-4.4.	Cross head plates inside Anchor Blocks.
1.2.2.4.1.1-4.5.	Anchor rods inside Anchor Blocks.
1.2.2.4.1.1-4.6.	Upper anchor plate inside Anchor Blocks.
1.2.2.4.1.1-4.7.	Anchor bolts inside Anchor Blocks.
Secondary elements	**Description**
1.1.2.1-2.??	Secondary steelwork within anchorages (including access doors)

1. General

This Technical Instruction (TI) has been developed to provide the detail necessary for competent persons to carry out inspection and maintenance activities on the main cables along the length from where the points where the cables enter the anchorages. This instruction includes for the Inspection and maintenance activities of the components anchoring the main cables and includes the splay saddle within the anchorages. Main cable elements outside of the anchorages are covered under separate TI 3.02.1.

If any aspect of this document is not clear to the person tasked with undertaking these inspection and maintenance activities it is incumbent upon that person to seek the necessary clarification before commencing work.

The Technical Manager is responsible for ensuring that inspection and maintenance activities are undertaken as required by the associated Technical Procedures and Instructions. The Technical Manager shall assess the need for follow up actions based on the inspections.

Component Sheets are to be developed for each of the bridge parts covered by this procedure. These component sheets will provide additional reference information on these parts.

2. Preparatory Work

Prior to commencing work on site, personnel are to ensure that they are familiar with all associated procedures for working on the structure. These will include:

TPXX Health and safety, including working at height, PPE. Weather restrictions on access.

TPXX Working procedures for the bridge, e.g. radio operation, site vehicles, access routes.

TPXX Use of access equipment, e.g. gantries, lifts.

TP 1.01 Principal Inspections (and Definitions of defect types, extent and severity ratings).

Personnel must also ensure they are familiar with the following:

a) Results of previous inspections of the Bridge Parts.

b) Details of the construction drawings and specification for the parts being inspected.

c) Details of any associated non-conformance issues raised during construction.

d) Location reference systems for the Bridge Parts being inspected.

e) Use of any proforma developed for the inspections. (see Appendix 1).

f) Checking and operation of equipment, e.g. cameras, batteries, calibration certificates.

g) Details of any repair or replacement work undertaken to the parts being inspected since the previous inspection.

h) Bridge Component Sheets for the parts being inspected.

3. Access for inspection

Access to enable the required inspections to be undertaken can be achieved by use of the access ways into the anchorages. Once inside the anchorages access will be via the access stairways and platforms provided. If necessary, a Visual Inspection (VI) can be improved by using binoculars from the nearest access position. Where a more detailed, Principal Inspection (PI) is required it may be necessary for additional access to be provided, e.g. scaffold.

4. Inspection Equipment

The following equipment should be available to the inspection team:

- Mandatory safety equipment.
- Air quality monitor.
- Site Radio.
- Clipboard.
- Inspection proforma and writing materials.
- 2m steel tape measure
- Camera with flash, zoom, date, video and audio capability.
- Torch with spare batteries.
- Binoculars.
- Cleaning Rags.
- Mirror on telescopic pole.
- Inspector's Aide Memoir with location reference details.

5. Categories of Inspections

Routine Inspections, Principal Inspections and Special Inspections will all be required at various times. Specific requirements for each are given below:

5.1 Routine Inspections

Routine Inspections are those inspections which are undertaken with a predefined scope and frequency. A Routine General Inspection is to be undertaken a two yearly intervals. This inspection is to be undertaken by the inspectors accessing the length of the main cable within the anchorages using a mirror to view areas as necessary.

It is suggested that the first such inspection is carried out to the anchorages at one side of the bridge after one year then alternating between each side of the bridge on a yearly cycle. The Routine General Inspections should be coordinated with the Principal Inspection requirement as set out in the Technical Procedure.

The inspection team will report to the Technical Manager on any condition that may warrant further investigation via a Special Inspection.

5.2 Principal Inspections

A Principal Inspection is a thorough inspection carried out by experienced Inspectors and undertaken within touching distance of the element being inspected. For the components covered by this Technical Instruction it will be necessary to ensure that suitable access is available to the inspection team.

A Principal Inspection is required every six years. It is suggested that the first such inspection is carried out to the main cable anchorages on one side of the bridge after three years then alternating between each side of the bridge on a three yearly cycle. In years when a Principal Inspection is carried out the annual Routine General Inspection may be omitted. The inspection team will report to the Technical Manager on any condition that may warrant further investigation via a special Inspection.

5.3 Special Inspections

Special inspections are all inspections which are not routine and will generally arise from defects or anomalies found during either Routine or Principal Inspections or arising from accidental damage. Special Inspections may also be required after specified extreme weather conditions but these have not been established for the bridge parts covered by the Technical Instruction.

Special Inspections arising from the findings of a Routine Inspection may require additional access to be provided. This will need to be assessed at the time.

Special Inspections arising from the findings of a Principal Inspection may make use of the access provided for the Principal Inspection if this is considered to be necessary.

Where defects are noted that require a Special Inspection, consideration should be given to inspecting the equivalent areas in the other anchorages.

6. Scope of Inspections

The general scope of inspection is given below for the Bridge Parts covered by this TI. Notwithstanding the work covered by the scope, Inspectors are expected to be vigilant at all times and to report anything that appears to require attention or further investigation. This shall include aspects of structural behaviour such as unusual vibrations, noise or deflections; it shall also include any localised element of a bridge part that appears different from the normal condition for that part.

The anchorages are de-humidified areas which rely upon maintaining a low level of relative humidity in the air to prevent any corrosion of the steel elements within the controlled environment. Any evidence of corrosion activity or any signs of water ingress should be reported and investigated.

a. Bridge Element 1.2.2.4.1.1.2. Main suspension cables (for the length not inspected under TI No.1.)

This Bridge Part is mainly within the anchorage chambers but will also apply to the entry length not inspected as part of the length between the anchorages. The cable will enter the anchorage, open up over the length of the splay saddle with the individual galvanised strands anchored at their lowest ends. All strands are to be visually inspected to identify any evidence of damage to the individual strands and wires or to their galvanised surfaces. The sockets at the end of each strand are to be inspected for any signs of damage but particularly for any evidence of socket draw. The configuration is expected to be such that access for inspectors will not be possible; use of endoscopes or other techniques may need to be investigated.

Details where cable enters the anchorage to be determined and inspection requirements included here.

b. Bridge Element 1.2.2.2.1. Splay saddles

The purpose of the splay saddle is to combine the individually anchored strands and to align them to the correct trajectory as they exit the anchorage. There is one splay saddle in each anchorage. They are a large steel fabricated assembly with layers of curved cast steel plates attached to the outer radius which act as supports and guides to the strands. The splay saddle has a knuckle joint abutting the concrete anchorage structure for the transfer of loads generated by the change in alignment of the main cable. Details are not yet determined to allow inspection to be described.

c. Bridge Element 1.2.2.4.1.1.4-7. Cable strand anchor rods, plates and bolts.

At the termination of each strand is a socket. This is tied back to the concrete anchorage by an assembly of various plates and bolts fixed to a number of rods tied into the concrete. Again, the configuration is expected to be such that access for inspectors will not be possible; use of endoscopes or other techniques may need to be investigated. Details are not yet determined to allow inspection to be described.

When planning these inspections, consideration should be given to carrying out inspections of other, non-structural, parts within these areas, e.g. access stairs and platforms, lighting, dehumidification, power outlets and maintenance of access points.

7. Recording of Inspections

It is essential that all defects and abnormalities noted during inspections are clearly recorded. Inspectors should ensure that the location, type, extent and severity of each defect is recorded and supported by a brief description and one or two supporting photographs. If the Inspector can clearly identify the cause of any reported defect then this should be included in the report. If the cause of any defect is unknown then this should be noted so that the need for a follow-on Special Inspection can be assessed.

It is also important that where an element has been inspected and no defect is found that this is also recorded.

Defects identified during previous inspections, but where no action was taken, should be re-inspected and given revised extent and severity ratings such that comparison can be made to earlier inspection records. The report should note the extent of deterioration.

All inspection reports shall be submitted to the Technical Manager and an assessment made of any required follow up activity.

Inspection staff are encouraged to include in their reports to the Technical Manager any comments on the effectiveness of this Technical Instruction and to suggest potential improvements.

8. Timing and Frequency of Inspections

The frequency of inspection of the above elements will vary over the lifetime of the bridge. Initially it is suggested that a visual inspection is undertaken at two-yearly intervals. If any areas of concern are noted from the visual inspection then a more detailed Principal Inspection may be warranted.

Special Inspections of these elements are not expected following extreme weather or following a reported incident. However, seismic activity may prompt particular inspections or investigations to be carried out.

9. Maintenance Activities

There are no scheduled regular maintenance requirements for the bridge parts covered by this Technical Instruction. All maintenance activities will be determined based on the findings of the above inspections and from any follow-on Special Inspections.

10 Info to be obtained

The following issues should be considered and addressed or dismissed prior to the finalisation of this TI.

- In cases of severe weather are any associated inspections required to be undertaken?
- Will any Structural Health readings prompt any associated inspections, e.g. seismic?
- Will permanent access be provided that is sufficient for close visual inspections?
- No seasonal constraints are envisaged for work in the anchorages.
- Details of anchorage arrangements to be determined to allow completion of this TI.
- Splay saddle details also required.

Appendix 1 – Inspection Proforma – see Section 2

A series of Inspection Proforma will be developed to cover all of the elements covered by this TI. The proforma will include clear identification of element and location, a summary of defect type, extent and severity together with reference to the associated photographs of the defects reported.

Appendix 5.10.F - Technical Instruction for inspection of internal elements of steel road girders, steel rail girders and steel cross girders

Technical Procedure TP No. 3.01

Technical Instruction TI 3.01.3

1. (P) MESSINA STRAIT BRIDGE DRAFT

2. (SV) SUPERSTRUCTURE

3. (I3) DECK – (Internal Surfaces)

TECHNICAL INSTRUCTION FOR INSPECTION OF INTERNAL ELEMENTS OF STEEL ROAD GIRDERS, STEEL RAIL GIRDER AND STEEL CROSS GIRDERS:

Primary Elements	**Description**
1.2.3.1 (P-SV-I3-CF)	Railway Girder – Internal surfaces.
1.2.3.2 (P-SV-I3-??)	Roadway Girder Sicily – Internal surfaces.
1.2.3.3 (P-SV-I3-??)	Roadway Girder Calabria – Internal surfaces.
1.2.3.4 (P-SV-I3-??)	Main Cross Girders – Internal surfaces.

Secondary Elements	**Description**
1.2.3.1-4.1-3.n.5 (??)	Secondary steelwork within girders (including access manholes)
1.4.3.2. (P-IT-M2-A5)	Surface Drainage (Elements within girders)

1. General

This Technical Instruction (TI) has been developed to provide the detail necessary for competent persons to carry out inspection and maintenance activities to the internal surfaces of the steel box girders of the bridge deck . This instruction includes for the Inspection and maintenance activities of the steel plates and associated steel sections that are welded or otherwise connected to form the basic structural steel box girder sections. The inspection and maintenance requirements for the external surfaces of these steel box girders are covered under separate TI 3.01.4.

If any aspect of this document is not clear to the person tasked with undertaking these inspection and maintenance activities it is incumbent upon that person to seek the necessary clarification before commencing work.

The Technical Manager is responsible for ensuring that inspection and maintenance activities are undertaken as required by the associated Technical Procedures and Instructions. The Technical Manager shall assess the need for follow up actions based on the inspections.

Component Sheets are to be developed for each of the bridge parts covered by this procedure. These component sheets will provide additional reference information on these parts.

2. Preparatory Work

Prior to commencing work on site, personnel are to ensure that they are familiar with all appropriate associated manuals and procedures for working on the structure. These will include:

TPXX Health and safety, including working in confined spaces, PPE. Weather restrictions on access.

TPXX Working procedures for the bridge, e.g. radio operation, site vehicles, access routes.

TPXX Use of access equipment, e.g. gantries, lifts.

TP1.01 Principal Inspections (and Definitions of defect types, extent and severity ratings).

TPXX

Personnel must also ensure they are familiar with the following:

a) Results of previous inspections of the Bridge Parts.

b) Details of the construction drawings and specification for the parts being inspected.

c) Details of any associated non-conformance issues raised during construction.

d) Location reference systems for the Bridge Parts being inspected.

e) Use of any proforma developed for the inspections. (see Appendix 1).

f) Checking and operation of equipment, e.g. cameras, batteries, calibration certificates.

g) Details of any repair or replacement work undertaken to the parts being inspected since the previous inspection. This will include repairs to road traffic barriers on carriageways above to enable inspection of associated internal areas.

h) Bridge Component Sheets for the parts being inspected. (see Appendix 1).

3. Access for inspection

Access to enable the required inspections to be undertaken can be achieved at a variety of locations across the whole length of the bridge. Visual Inspection (VI) and Close Visual Inspection (CVI) can be undertaken by walking through the various boxes using the internal lighting supplemented by hand held torches. Where a more detailed, Principal Inspection (PI) is required, closer access to the underside of the deck plate may involve the use of portable steps or a moveable platform.

4. Inspection Equipment

The following equipment should be available to the inspection team:

- Mandatory safety equipment.
- Site Radio.
- Clipboard.
- Inspection proforma and writing materials.
- 2m steel tape measure.
- Weld gauge to check weld throat thickness and leg lengths.
- Camera with flash, zoom, date, video and audio capability.
- Torch with spare batteries.
- Cleaning Rags.
- Inspector's Aide Memoir with defect and location reference details.

5. Categories of Inspections

Routine Inspections, Principal Inspections and Special Inspections will all be required at various times. Specific requirements for each are given below:

5.1 Routine Inspections

Routine Inspections are those inspections which are undertaken with a predefined scope and frequency. For the components covered by this Technical Instruction a Routine General Inspection will be required, for the initial period of operation, at two-yearly intervals. This inspection will require all elements to be visually inspected by walking through each section, viewing all components and noting any anomalies in the condition of the steel elements.

Particular attention shall be given to the following:

- Welds of the trough stiffeners to the deck plate along the lines of the wheel tracks of the HGV carriageway above.
- Welds of the stiffeners under the railway tracks.
- Areas where a traffic incident may have occurred since a previous inspection.
- Areas of concern as noted in previous inspections.
- Areas identified during construction as meriting closer inspections.

The Routine General Inspections should be coordinated with the Principal Inspection requirement set out below.

The inspection team will report to the Technical Manager on any condition that may warrant further investigation via a special Inspection.

5.2 Principal Inspections

A Principal Inspection is required every six years and will involve a close visual inspection being carried out by experienced Inspectors and undertaken within touching distance of the element being inspected. For the underside of the deck plate, this may require some additional access equipment to be available. Particular attention shall again be given to the areas noted above.

The inspection team will report to the Technical Manager on any condition that may warrant further investigation via a special Inspection.

5.3 Special Inspections

Special inspections are all inspections which are not routine and will generally arise from defects or anomalies found during either Routine or Principal Inspections or arising from accidental damage. Where potential weld defects have been noted during routine inspections, some non-destructive testing such as Magnetic Particle Inspection (MPI) or Ultrasonic Testing (UT) may be required.

Special Inspections may also be developed from Reliability Based Inspections. RBI covers systems and elements with a predictable failure pattern, where the degradation rate can be measured and is particularly beneficial for multiple repetitive elements. Under RBI, Special Inspections are undertaken on a number of representative areas where close visual inspections and specific testing and measurements can be carried out to produce a condition indicator. The other areas are inspected less thoroughly, e.g. visual inspection, sufficient to identify any large deviations from the standard of the selected reference areas. In this way for example, the development of fatigue cracking in the most vulnerable or critical welds could be identified promptly.

Special Inspections may also be required after specified extreme weather conditions but these have not been established for the bridge parts covered by the Technical Instruction.

6. Scope of Inspections

The general scope of inspection is given below for the Bridge Parts covered by this TI. Notwithstanding the work covered by the scope, Inspectors are expected to be vigilant at all times and to report anything that appears to require attention or further investigation. This shall include aspects of structural behaviour such as unusual vibrations, noise or deflections; it shall also include any localised element of a bridge part that appears different from the normal condition for that part.

6.1 Associated Inspections

When undertaking inspections covered by this TI access will be required throughout all the internal areas of the box girders. The following items should therefore also be inspected as part of this work:

- Inspection of secondary steelwork elements, e.g. access stairs, ladders, platforms.
- Inspection of all associated access entry and egress points.
- Visual inspection of all internal surface water drainage pipes,
- Visual Inspection of other services, ducts and cables.

Consideration should also be given to including the following activities during these inspections:

- Functional inspection of all internal lighting.
- Functional inspection of all internal power points.

6.2 General Scope of Inspections

The areas covered by the Technical Instruction are all of a similar basic form. Stiffened steel plates have been welded together under factory conditions to form a series of boxes, these boxes have been connected together to form the bridge deck with traffic allowed to travel upon the top deck plate. The welded connections between individual prefabricated deck sections will have been made on site and as such may be of a lesser standard than the factory welds. Where traffic is carried by the top plate of the box girder the plates and welds below the traffic loads and the rail loads will be more susceptible to fatigue and deterioration than would be expected for other areas. For this reason, the inspection requirements to these areas are greater than for most other surfaces within the box girders. However, variability in the quality of materials and workmanship may also become apparent in time and as such other sections may, at some time in the future, warrant more frequent inspections.

The internal surfaces of the box girders are protected against corrosion by the application of a paint system and also by dehumidification. For this to be effective, the relative humidity within the box girders needs to be controlled and kept at a level at which corrosion cannot occur. There is a benefit in having the surfaces painted in a light colour as it will make inspection much easier as all surfaces should have a common appearance and any defect should be easier to identify.

6.3 Detailed Scope of Inspections

The initial inspection of the internal surfaces should record the base condition of the internal surfaces including the extent of damaged paintwork and any construction related deformation, scars or gouges in the steel plates or sections; this will enable any future damage or deterioration to be identified and its cause investigated. Similar attention should be given to all access points as these will be susceptible to damage from heavy use which may allow water ingress and local corrosion.

Inspection staff should be vigilant during all inspections. It should be noted that these particular inspections will be extremely repetitive and this concern should be understood when planning the work. Construction records should be reviewed to identify any particular elements which gave cause for concern during the construction phase; such areas may warrant particular vigilance.

The purpose of the visual inspections is to identify any change occurring to the structure. The benefit of having confidence in a thorough initial inspection will allow future reported deterioration to be recognised as a change and not confused with a possible missed construction related issue.

Before commencing an inspection, a review should be made of any road traffic incidents where barrier repairs have been undertaken; at such locations particular attention should be given to the area below the barrier repairs to note any signs of internal damage.

The box sections will have a design life of 200 years but should be expected to require increasing levels of maintenance as the age of the bridge increases.

When planning these inspections, consideration should be given to carrying out inspections of other, non-structural, parts within these areas, e.g. lighting, dehumidification, power outlets and maintenance of access points.

6.4 Inspection of non-standard areas.

NOTE: The above requirements have assumed that all deck box girder sections are repetitive, with generally common layouts throughout the length of the structure. Some areas may have different layouts which may need additional commentary on inspection and reporting requirements. This will need to be addressed as the detailed design becomes more finalised.

7. Recording of Inspections

It is essential that all defects and abnormalities noted during inspections are clearly recorded. Inspectors should ensure that the location, type, extent and severity of each defect is recorded and supported by a brief description and one or two supporting photographs. If the Inspector can clearly identify the cause of any reported defect then this should be included in the report. If the cause of any defect is unknown then this should be noted so that the need for a follow-on Special Inspection can be assessed.

It is important that where an element has been inspected and no defect is found that this is also recorded. Similarly, if any area was not able to be inspected, this should also be reported together with the reason.

Defects identified during previous inspections, but where no action was taken, should be re-inspected and given revised extent and severity ratings such that comparison can be made to earlier inspection records. The report should note the extent of any deterioration.

All inspection reports shall be submitted to the Technical Manager and an assessment made of any required follow up activity.

Inspection staff are encouraged to include in their reports to the Technical Manager any comments on the effectiveness of this Technical Instruction and to suggest potential improvements.

8. Timing and Frequency of Inspections

The frequency of inspection of the above elements will vary over the lifetime of the bridge. Initially it is suggested that routine inspections are undertaken at two-yearly intervals and principal inspections at six-yearly intervals. However, these may be programmed as a rolling programme of inspection. Following the first cycle of principal inspections there may be the opportunity to decrease the number of routine inspections or to target such inspections to particular areas. Over time, and depending upon the amount of defects reported, it may be possible to decrease the number of inspections. However, once fatigue type defects begin to develop there will be an increasing need for additional, i.e. more frequent, inspections

Special Inspections may be required following extreme weather, seismic activity or following a reported incident.

9. Maintenance Activities

There are no scheduled regular maintenance requirements for the bridge parts covered by this Technical Instruction. All maintenance activities will be determined based on the findings of the above inspections and from any follow-on Special Inspections.

Anticipated maintenance will include:

- Minor repairs to the internal paint system.
- Weld repairs to top deck plate welds. (Note: there is a requirement to inspect the carriageway surfacing along the line of a weld repair to the deck plate.)
- Other weld repairs. (Note: these may damage the paint system on the external surfaces.)
- Sealing of access points.

10 Info to be obtained

The following issues should be considered and addressed or dismissed prior to the finalisation of this TI.

- In cases of severe weather are any associated inspections required to be undertaken?
- Will any Structural Health readings prompt any associated inspections?
- Will the dehumidification systems give an alert for e.g. possible water ingress and location details?
- Are any seasonal or other constraints envisaged for work within the deck boxes? E.g. internal summer temperatures, noise within boxes from road or rail traffic overhead.
- If an internal drainage system is adopted, how would an overflow or broken pipe be identified?

Appendix 1 – Inspection Proforma – see Section 2

A series of Inspection Proforma will be developed to cover all of the elements covered by this TI. The proforma will include clear identification of element and location, a summary of defect type, extent and severity together with reference to the associated photographs of the defects reported.

Appendix 5.10.G - Technical Instruction for inspection of external elements of steel road girders, steel rail girder and steel cross girders

Technical Procedure TP No. 3.01

Technical Instruction TI 3.01.4

1. (P) MESSINA STRAIT BRIDGE DRAFT

2. (SV) SUPERSTRUCTURE

3. (I3) DECK – (External Surfaces)

TECHNICAL INSTRUCTION FOR INSPECTION OF EXTERNAL ELEMENTS OF STEEL ROAD GIRDERS, STEEL RAIL GIRDER AND STEEL CROSS GIRDERS:

Primary Elements	Description
1.2.3.1 (P-SV-I3-CF)	Railway Girder - external painted surfaces and platforms.
1.2.3.2 (P-SV-I3-??)	Roadway Girder Sicily - external surfaces.
1.2.3.3. (P-SV-I3-??)	Roadway Girder Calabria - external surfaces.
1.2.3.4. (P-SV-I3-TP)	Main Cross Girders - external surfaces.

Secondary Elements	Description
1.3.1.1. (P-SS-R4-CR)	Service lane
1.3.1.2. (P-SS-R4-BF)	Wind Screens

1. General

This Technical Instruction (TI) has been developed to provide the detail necessary for competent persons to carry out inspection and maintenance activities to the external painted surfaces of the steel box girders. This instruction includes for the Inspection and maintenance of the secondary steel structures attached to the roadway girders, i.e. the service lane (1.3.1.1.) (P-SS-R4-CR) and the wind screens (1.3.1.2.)(P-SS-R4-BF). This instruction will also include the visual inspection of the gantry support rails and their connection to the deck – but not the gantry structure or any associated load testing. The inspection and maintenance requirements for the internal surfaces of these steel box girders are covered under separate TI 3.01.3. The inspection and maintenance requirements for those parts which are unpainted but where surfacing has been applied are also covered under separate TIs. (Ref: YYY).

If any aspect of this document is not clear to the person tasked with undertaking these inspection and maintenance activities it is incumbent upon that person to seek the necessary clarification before commencing work.

The Technical Manager is responsible for ensuring that inspection and maintenance activities are undertaken as required by the associated Technical Procedures and Instructions. The Technical Manager shall assess the need for follow up actions based on the inspections.

Component Sheets are to be developed for each of the bridge parts covered by this procedure. These component sheets will provide additional reference information on these parts. (See Appendix 1).

2. Preparatory Work

Prior to commencing work on site, personnel are to ensure that they are familiar with all associated manuals and procedures for working on the structure. These will include:

TPXX Health and safety, including working in confined spaces, PPE. Weather restrictions on access.

TPXX Working procedures for the bridge, e.g. radio operation, site vehicles, access routes.

TPXX Use of access equipment, e.g. gantries, lifts.

TP1.01 Principal Inspections (and Definitions of defect types, extent and severity ratings).

TPXX

Personnel must also ensure they are familiar with the following:

a) Results of previous inspections of the Bridge Parts.

b) Details of the construction drawings and specification for the parts being inspected.

c) Details of any associated non-conformance issues raised during construction.

d) Location reference systems for the Bridge Parts being inspected.

e) Use of any proforma developed for the inspections. (see Appendix 1).

f) Checking and operation of equipment, e.g. cameras, batteries, calibration certificates.

g) Details of any repair or replacement work undertaken to the parts being inspected since the previous inspection.

h) Bridge Component Sheets for the parts being inspected.

i) Any special inspection requirements for the gantry support rails that may be included within the associated gantry manuals.

3. Access for inspection

Access to enable the required inspections to be undertaken will mainly rely upon the use of the underdeck travelling gantry systems that have been provided for this purpose. Some areas covered by this TI will be inspected from the service lanes but most inspections and associated maintenance will be undertaken from the gantries.

4. Inspection Equipment

The following equipment should be available to the inspection team:

- Mandatory safety equipment.
- Site Radio.
- Clipboard.
- Inspection proforma and writing materials.
- 2m steel tape measure.
- Weld gauge to check weld throat thickness and leg lengths.
- Paint thickness gauge to measure deterioration of the paint system.
- Camera with flash, zoom, date, video and audio capability.
- Cleaning Rags.
- Inspector’s Aide Memoir with defect and location reference details.

5. Categories of Inspections

Routine Inspections, Principal Inspections and Special Inspections will all be required at various times. Specific requirements for each are given below:

5.1 Routine Inspections

Routine Inspections are those inspections which are undertaken with a predefined scope and frequency. For the components covered by this Technical Instruction a Routine General Inspection will be required, for the initial period of operation, at two-yearly intervals. This inspection will require all elements to be visually inspected by taking the gantry along each section, viewing all components and noting any anomalies in the condition of the steel elements or the painted surfaces.

Particular attention shall be given to the following:

- Condition of the paint and any areas of damage, discolouration or staining.
- Welds, particularly site welded connections.
- Areas where a traffic incident may have occurred since a previous inspection.
- Areas around entry access points.
- Areas around lower hanger anchorages.
- Areas of concern as noted in previous inspections.
- Areas identified during construction as meriting closer inspections.

The Routine General Inspections should be coordinated with the Principal Inspection requirement set out below.

The inspection team will report to the Technical Manager on any condition that may warrant further investigation via a special Inspection.

5.2 Principal Inspections

A Principal Inspection is required every six years and will involve a close visual inspection being carried out by experienced Inspectors and undertaken within touching distance of the element being inspected.

The inspection team will report to the Technical Manager on any condition that may warrant further investigation via a special Inspection.

5.3 Special Inspections

Special inspections are all inspections which are not routine and will generally arise from defects or anomalies found during either Routine or Principal Inspections or arising from accidental damage. Where potential weld defects have been noted during routine inspections, some non-destructive testing such as Magnetic Particle Inspection (MPI) or Ultrasonic Testing (UT) may be required.

Special Inspections may also be developed from Reliability Based Inspections. RBI covers systems and elements with a predictable failure pattern, where the degradation rate can be measured and is particularly beneficial for multiple repetitive elements. Under RBI, Special Inspections are undertaken on a number of representative areas where close visual inspections and specific testing and measurements can be carried out to produce a condition indicator. The other areas are inspected less thoroughly, e.g. visual inspection, sufficient to identify any large deviations from the standard of the selected reference areas. In this way for example, the rate of deterioration of the paint system can be assessed or the development of fatigue cracking in the most vulnerable or critical welds could be identified promptly.

Special Inspections may also be required after specified extreme weather conditions but these have not been established for the bridge parts covered by the Technical Instruction.

6. Scope of Inspections

The general scope of inspection is given below for the Bridge Parts covered by this TI. Notwithstanding the work covered by the scope, Inspectors are expected to be vigilant at all times and to report anything that appears to require attention or further investigation. This shall include aspects of structural behaviour such as unusual vibrations, noise or deflections; it shall also include any localised element of a bridge part that appears different from the normal condition for that part.

6.1 Associated Inspections

When undertaking inspections covered by this TI access will be required along all the external areas of the box girders and cantilever sections. Consideration should be given to including the following activities during these inspections:

- Functional inspection of all associated access entry and egress points.
- Visual inspection of all associated external service pipes, ducts and service cables.
- Visual inspection of the outer surfaces of wind barriers and other items that are best viewed from the gantry.

6.2 General Scope of Inspections

The areas covered by the Technical Instruction are all of a similar basic form. Stiffened steel plates have been welded together under factory conditions to form a series of boxes, these boxes have been connected together to form the bridge deck with traffic allowed to travel upon the top deck plate. The welded connections between individual prefabricated deck sections will have been made on site and as such may be of a lesser standard than the factory welds. Other variations in the quality of materials and workmanship may also become apparent in time and as such some areas may, at some time in the future, warrant more frequent inspections.

The external surfaces of the box girders are protected against corrosion by a paint system. This will have a finite service life, with replacement of the top coat envisaged after twenty years. Patch painting may also be applied for a number of years to defer the need for a complete repaint of the structure. Most initial painting would be undertaken at the fabrication stage in purpose built paint shops with good quality control. Site painting will have been necessary at particular areas, such as the site welded joints and areas where damage may have necessitated remedial work during construction. The quality of application will be expected to be lower at these locations; inspectors should therefore give these areas a closer inspection. Reliability Based Inspection (RBI) may be applied to the paint system on the external surfaces of the bridge deck and towers.

The gantries used for these inspection activities will be carried by rails attached to the bridge structure. Inspectors shall consider these rails as structural elements and visually inspect them for defects as part of this TI.

Unpainted surfaces will generally include the top surfaces of these box girder elements where surfacing has been applied. Inspection of these surfaces will be included with TIs prepared for carriageway inspections. If as result of those inspections there are concerns reported of possible defects with the deck plates then Special Inspections will be undertaken as appropriate.

6.3 Detailed Scope of Inspections

The initial inspection of the external surfaces should record the base condition of the external painted surfaces including any construction related deformation, scars or gouges in the steel plates or sections; this will enable any future damage or deterioration to be identified and its cause investigated. Similar attention should be given to all access points as these will be susceptible to damage from heavy use which may allow water ingress and local corrosion.

Inspection staff should be vigilant during all inspections. It should be noted that these particular inspections will be extremely repetitive and this concern should be understood when planning the work. Construction records should be reviewed to identify any particular elements which gave cause for concern during the construction phase; such areas may warrant particular vigilance.

The purpose of the visual inspections is to identify any change occurring to the structure. The benefit of having confidence in a thorough initial inspection will allow future reported deterioration to be recognised as such and not confused with a possible missed construction related issue.

The box sections and cantilever elements will have a design life of 200 years but will require increasing levels of maintenance as the age of the bridge increases. The gantry rails may be expected to deteriorate over time but are considered to be replaceable parts.

6.4 Inspection of non-standard areas.

NOTE: The above requirements have assumed that all deck box girder sections are repetitive, with generally common layouts throughout the length of the structure. Some areas may have different layouts which may need additional commentary on inspection and reporting requirements. This will need to be addressed as the detailed design becomes more finalised.

7. Recording of Inspections

It is essential that all defects and abnormalities noted during inspections are clearly recorded. Inspectors should ensure that the location, type, extent and severity of each defect is recorded and supported by a brief description and one or two supporting photographs. If the Inspector can clearly identify the cause of any reported defect then this should be included in the report. If the cause of any defect is unknown then this should be noted so that the need for a follow-on Special Inspection can be assessed.

It is also important that where an element has been inspected and no defect is found that this is also recorded.

Defects identified during previous inspections, but where no action was taken, should be re-inspected and given revised extent and severity ratings such that comparison can be made to earlier inspection records. The report should note the extent of any deterioration.

All inspection reports shall be submitted to the Technical Manager and an assessment made of any required follow up activity.

Inspection staff are encouraged to include in their reports to the Technical Manager any comments on the effectiveness of this Technical Instruction and to suggest potential improvements.

8. Timing and Frequency of Inspections

The frequency of inspection of the above elements will vary over the lifetime of the bridge. Initially it is suggested that routine inspections are undertaken at two-yearly intervals and principal inspections at six-yearly intervals. However, these may be programmed as a rolling programme of inspection. Following the first cycle of principal inspections there may be the opportunity to decrease the number of routine inspections or to target such inspections to particular areas. Over time, and depending upon the amount of defects reported, it may be possible to decrease the number of inspections. However, once fatigue type defects begin to develop there will be an increasing need for additional, i.e. more frequent, inspections

Special Inspections may be required following extreme weather, seismic activity or following a reported incident.

9. Maintenance Activities

There are no scheduled regular maintenance requirements for the bridge parts covered by this Technical Instruction. All maintenance activities will be determined based on the findings of the above inspections and from any follow-on Special Inspections.

Anticipated maintenance will include:

- Repainting of top coat of paint after approximately twenty years.
- Patch painting repairs.
- Weld repairs.
- Repair of seals at access points.
- Repainting at paint system life cycle intervals.

10 Info to be obtained

The following issues should be considered and addressed or dismissed prior to the finalisation of this TI.

- Top surface of the rail box girder to be considered, i.e. details of corrosion protection system? How to access??
- Should the inspection of the platform along the railway be included, i.e. inspect from the gantry?
- Top surface of cross beams – are these best viewed from the gantries? Could the platform be better??
- Street lighting columns – how are these inspected and can their deck connections be included as part of this TI?
- Wind barriers – should view outer areas when using the gantries – remainder to include here - at 2 years and 6 years PI??
- Decking on service lane is grating – what are inspection needs – fixings etc?
- In cases of severe weather are any associated inspections required to be undertaken?
- Will any Structural Health readings prompt any associated inspections?
- Are any seasonal or other constraints envisaged for work from these gantries, E.g. wind?

Appendix 1 – Inspection Proforma – see Section 2

A series of Inspection Proforma will be developed to cover all of the elements covered by this TI. The proforma will include clear identification of element and location, a summary of defect type, extent and severity together with reference to the associated photographs of the defects reported.

Appendix 5.10.H - Technical Instruction for inspection of Roadway Crash Barriers

Technical Procedure TP No. 4.01

Technical Instruction TI 4.01.1

1. (P) MESSINA STRAIT BRIDGE DRAFT

3. (S6) SECONDARY SYSTEM

1. (R4) SECONDARY STRUCTURES

3. (BA) ROADWAY BARRIERS

TECHNICAL INSTRUCTION FOR INSPECTION OF ROADWAY BARRIERS

Primary Element	**Description**
1.3.1.3.	Roadway Barriers

1. General

This Technical Instruction (TI) has been developed to provide the detail necessary for competent persons to carry out inspection and maintenance activities to the roadway barriers along both sides of each carriageway for the length of the bridge from anchorage to anchorage. This instruction includes for the Inspection and maintenance activities of the barrier rails and associated steel sections that are welded or otherwise connected to base plates positioned above internal diaphragms within the structural steel box girder carriageway sections.

If any aspect of this document is not clear to the person tasked with undertaking these inspection and maintenance activities it is incumbent upon that person to seek the necessary clarification before commencing work.

The Technical Manager is responsible for ensuring that inspection and maintenance activities are undertaken as required by the associated Technical Procedures and Instructions. The Technical Manager shall assess the need for follow up actions based on the inspections.

Component Sheets are to be developed for each of the bridge parts covered by this procedure. These component sheets will provide additional reference information on these parts.

2. Preparatory Work

Prior to commencing work on site, personnel are to ensure that they are familiar with all associated procedures for working on the structure. These will include:

TPXX Health and safety, including working in confined spaces, PPE. Weather restrictions on access.

TPXX Working procedures for the bridge, e.g. radio operation, site vehicles, access routes.

TPXX Use of access equipment, e.g. gantries, lifts.

TP1.01 Principal Inspections (and Definitions of defect types, extent and severity ratings).

TPXX

Personnel must also ensure they are familiar with the following:

a) Results of previous inspections of the Bridge Parts.

b) Details of the construction drawings and specification for the parts being inspected.

c) Details of any associated non-conformance issues raised during construction.

d) Location reference systems for the Bridge Parts being inspected.

e) Use of any proforma developed for the inspections. (see Appendix 1).

f) Checking and operation of equipment, e.g. cameras, batteries, calibration certificates.

g) Details of any repair or replacement work undertaken to the parts being inspected since the previous inspection.

h) Bridge Component Sheets for the parts being inspected.

3. Access for inspection

Access to enable the required routine inspections to be undertaken can be achieved by using a vehicle driven along the carriageway. For principal inspections carriageway restrictions should be imposed to create a safe working area to allow the more detailed inspection to take place. Special Inspections may involve closing of one or more lanes or possibly by means of a rolling road block that could provide the time necessary to inspect a particular item.

4. Inspection Equipment

The following equipment should be available to the inspection team:

- Mandatory safety equipment.
- Site Radio.
- Clipboard.
- Inspection proforma and writing materials.
- 2m steel tape measure.
- Weld gauge to check weld throat thickness and leg lengths.
- Camera with flash, zoom, date, video and audio capability.
- Torch with spare batteries.
- Cleaning Rags.
- Inspector's Aide Memoir with location reference details.

Not all the above equipment will be required for all inspections.

5. Categories of Inspections

Routine Inspections, Principal Inspections and Special Inspections will all be required at various times. Specific requirements for each are given below:

5.1 Routine Inspections

Routine Inspections are those inspections which are undertaken with a predefined scope and frequency. For the components covered by this Technical Instruction a Routine Superficial Inspection will be required at least once per day. This inspection will require all elements to be visually inspected by driving over the full length of the bridge in each direction, viewing all components and noting any anomalies in the condition of the barriers. Particular attention shall be given to signs of impact damage.

The inspection team will inform the Technical Manager of any condition that may warrant further investigation via a special Inspection, such initial special inspections shall, where possible, be undertaken later that day or as soon as is practical.

When a road traffic incident is reported to the control centre a special inspection shall be undertaken as part of the incident recovery process to make use of any emergency traffic restrictions. Where repairs are required these will be temporarily carried out to allow the restrictions to be reduced or removed. Permanent repairs shall be instigated as required by the O&E Manual.

Road traffic incidents that generate barrier repairs should be recorded and advised to the teams inspecting the internal surfaces of the deck boxes to allow either a special inspection to be undertaken to the associated internal element or for such an inspection to be incorporated into the next routine or principal inspection planned for the internal box girder surfaces.

5.2 Principal Inspections

A Principal Inspection is required every six years and will involve a close visual inspection being carried out by experienced Inspectors and undertaken within touching distance of the element being inspected. For the carriageway barriers it is expected that cleaning will be required from time to time; the barriers could have a principal inspection programmed to coincide with the cleaning activity.

The inspection team will report to the Technical Manager on any condition that may warrant further investigation via a special Inspection.

5.3 Special Inspections

Special inspections are all inspections which are not routine and will generally arise from defects or anomalies found during either Routine or Principal Inspections or arising from reports of road traffic incidents.

Special Inspections may also be required after specified extreme weather conditions but these have not been established for the bridge parts covered by the Technical Instruction.

6. Scope of Inspections

The general scope of inspection is given below for the Bridge Parts covered by this TI. Notwithstanding the work covered by the scope, Inspectors are expected to be vigilant at all times and to report anything that appears to require attention or further investigation. This shall include aspects of structural behaviour such as unusual vibrations, noise or deflections; it shall also include any localised element of a bridge part that appears different from the normal condition for that part.

6.1 Associated Inspections

When undertaking the routine superficial inspections covered by this TI, consideration should be given to including the following activities:

- Functional inspection of all associated carriageway lighting, (if activated).
- Routine superficial inspection of carriageway surfacing, road markings and debris.
- Functional inspection of all activated Variable Message Signs (VMS).
- Routine superficial inspection of all road signs.

6.2 General Scope of Inspections

The components covered by the Technical Instruction are provided to give protection not only to the structural elements but also to the travelling public whose vehicles may impact these barriers. In order for these barriers to operate as intended, it is essential for any damage to be identified promptly and a follow up repair instigated immediately. Routine inspections are required to seek to identify any anomalies with the barriers; these can be investigated in more detail by a Special Inspection.

7. Recording of Inspections

It is essential that all defects and abnormalities noted during inspections are clearly recorded. Inspectors should ensure that the location, type, extent and severity of each defect is recorded and supported by a brief description and one or two supporting photographs. If the Inspector can clearly identify the cause of any reported defect then this should be included in the report. If the cause of any defect is unknown then this should be noted so that the need for a follow-on Special Inspection can be assessed.

It is also important that where an element has been inspected and no defect is found that this is also recorded.

Defects identified during previous inspections, but where no action was taken, should be re-inspected and given revised extent and severity ratings such that comparison can be made to earlier inspection records. The report should note the extent of any deterioration.

All inspection reports shall be submitted to the Technical Manager and an assessment made of any required follow up activity.

Inspection staff are encouraged to include in their reports to the Technical Manager any comments on the effectiveness of this Technical Instruction and to suggest potential improvements.

8. Timing and Frequency of Inspections

The frequency of inspection of the above elements is not expected to vary over the lifetime of the bridge.

Special Inspections may be required following extreme weather, seismic activity or following a reported incident.

9. Maintenance Activities

There are no scheduled regular maintenance requirements for the bridge parts covered by this Technical Instruction. All maintenance activities will be determined based on the findings of the above inspections and from any follow-on Special Inspections.

Anticipated maintenance will include:

- Repair or replacement of parts damaged by impact. Manufacturer required to provide details.
- Repairs to the corrosion protection system.
- Possible cleaning by pressure wash or similar once per year.

10 Info to be obtained

The following issues should be considered and addressed or dismissed prior to the finalisation of this TI.

- In cases of severe weather are any associated inspections required to be undertaken?
- If barrier repairs are required, is there a defined repair period, e.g. repairs must be completed with 72 hours of an incident.
- Are the units painted – and hence more likely to require cleaning?

Appendix 1 – Inspection Proforma – see Section 2

A series of Inspection Proforma will be developed to cover all of the elements covered by this TI. The proforma will include clear identification of element and location, a summary of defect type, extent and severity together with reference to the associated photographs of the defects reported.

Appendix 5.10.I - Technical instruction on reporting of Principal Inspection

Technical Procedure TP No. 1.01

Technical Instruction TI 1.01.1

TECHNICAL INSTRUCTION FOR REPORTING OF PRINCIPAL INSPECTION

1. User of Instruction

This instruction is prepared to instruct inspectors on how to report by the *Principal Inspection Report.*

2. References to Inspection Procedures and Instructions

TP 1.01: Technical Procedure, Principal Inspection

3. Instruction on Reporting

All Principal Inspections shall be concluded by entering the data according to the attached scheme "Principal Inspection Report"

Below is a brief instruction on which data to be reported:

Cell	Explanation
Principal Inspection Report	
Document no. XXXX	No. given according to the relevant QA document numbering system
Date	The date the Principal Inspection Report is issued
Subject of inspection	Hierarchy number and description of element (upper levels)
Inspector	Name and position of the inspector to be indicated
Period of inspection	The period is summarised from the inspection records
Requisition of Inspection	Normally this cell is filled in with the position of an employee of the Inspection & Maintenance Organisation.

Cell	Explanation
Required inspection frequency	Frequency according to TP zzz to be indicated
Date of last Inspections	The reports from Principal Inspections and other inspections to be browsed before the inspection. The date to be indicated.
Brief summary of last observations of inspections	A brief summary should be made of defects recorded the inspections since the last principal inspection. The inspector should investigate and note later agreements on rectification of the defects.
Brief summary of last observations of principal inspection	A brief summary should be made of defects recorded the last principal inspection. The inspector should investigate and note later agreements on rectification of the defects.
References to O&E and I&M manuals	References to Procedures and Instructions in Operation & Maintenance and Inspection & Maintenance Manuals to be indicated
Safety Instructions	Nos. should be indicated of the Safety Instructions to observe at the particular inspection
Traffic Restrictions	Nos. should be indicated of the Traffic Restriction Plans to observe at the particular inspection
Principal Inspection Records	The table shall indicate information on each individual inspected element given by the upper covering level.
Principal Inspection Record, ref. attached Appendix 1	
Report No.	No. of attached Principal Inspection Record to be indicated
Element no.	Element identification no. at the upper three levels to be indicated each level four element
Defect no.	Reference number for each defect description. These numbers do not necessarily need to be related to the individual damage nos. noted in the defect record.

Cell	Explanation
Defect description	A summary of the defect descriptions indicated in the defect record should be indicated each element at level 4
Defect cause	A summary of the defect causes indicated in the defect record should be indicated each element at level 4
Condition rating	Condition rating should be indicated according to the inspector's engineering judgement from the principles indicated in TP 1.01 sect. 5.3.4.
Special Inspection	If a special inspection is required to investigate the defects in more detail, the type of special investigation should be indicated according to the types explained in TP 1.01 sect. 5.3.6
Repair work	Type, quantity, year for performance, and according cost + time estimate should be indicated according to the inspector's engineering judgement for repair works needed to rectify the actual damages.
Photos	For each type of defect the number of photos should be indicated. The number is counted in the attached defect records.
Next year of inspection	The inspector's recommendation on next year of inspection should be indicated.
Defect Record, ref. attached Appendix 2	
Principal Inspection Report	The number of the report should be indicated on the record
Appendix no.	Number to be indicated by level and element number
Date	Date of inspection of specified element
Inspector	Initials
Inspected element	The findings are recorded on site by element level nos. and location nos. in the sequence they are observed. Element nos. and location codes according to I&M Manual section 4.
Defect no.	Each defect to be given sequential numbers within each element
Defect	Defect types to be recorded by their codes only if they are

Cell	Explanation
type/description	identical to those described in the TP 1.01 sect. 5.3.3 Classification of defects. Other defects should be indicated by a brief description.
Defect cause	The likely cause of the defect should be indicated according to the inspector's engineering judgement. Defects, which have been recorded in earlier reports, should be repeated whenever they have not been rectified or the defect has been required no action. Also any development, if any, in the extent of damage should be recorded.
Defect extent	Extent of defects to be indicated, reference to TP 1.01, sect. 5.3.5, Extent of Defects.
Condition rating	Condition rating should be indicated according to the inspector's engineering judgement from the principles indicated in TP 1.01 sect. 5.3.4.
Photo no.	Identification should be indicated by element no. and time.
Quantity	Quantities should be estimated/measured to such a detail that they can form basis for a requisition to a contractor.

Principal Inspection Report no. XXXX Date dd.mm.yy

Subject of Inspection			
Element No.			
Inspector	Department:		
Position:		Name:	
Period of Inspection :			

Requisition of Inspection

Required by		Date of Requisition:	

Department	Position	Name

Principal Inspection Planning

Required Inspection frequency:		
Date of last Inspection:	Principal Inspection.	Other Inspection
Brief summary of last observations:		

Reference to Inspection & Maintenance Manual

Technical Procedure ID	**Technical instruction ID**	**Technical instruction ID**		

References to Operation & Emergency Manual

Element no.	Unit	Supplier	Manual ID

Reference to Safety Precaution Instruction and Traffic Restriction requirements from Operation & Emergency Manual

Instruction ID	Subject

Principal Inspection Records

Date	Weather conditions	Inspected elements	Element no.

Appendices:

Appendix 1: Principal Inspection Record

Appendix 2: Record of Defects

Maintenance and Inspection - Principal Inspection Record
Report no.

Element no.					Description	Defect			Condition	Special	Repair Work					Photos	Next
L 1	L 2	L 3	L4	L5	Hierarchy	No	Description	Cause	Rating	Inspection						Ref.	Insp.
ID	ID	ID	ID	ID					(1-5)	A/B/C/D	Type	Labour	Time	Materi als	Cost	Nos	Year

Inspection Report no.			Date		Inspector	
Inspected element level 5		Inspected element	level 1	level 2	level 3	level 4
					Appendix no.	

Inspected element			Defect						Photo	Location codes						Repair Work		
level 6	level 7	level 8	No.	Type	Description	Defect cause	Extent	Condition Rating	No.	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	Labour	Time	Materials

Appendix 5.10.J - List of Technical Procedures and Instructions

List of Technical Procedures and Technical Instructions

INSPECTION

TP 1.01 Principal Inspection
- TI 1.01.1 Instruction on Reporting
- TI 1.01.2 Photo and video registration

TP 1.02 Supervision Report for Repair Works

CONCRETE

TP 2.01 Inspection of concrete structures
- TI 2.01.1 Inspection of piers and tower foundations
- TI 2.01.2 Inspection of anchor blocks

TP 2.02 Repair of concrete structures
- TI 2.02.1 Repair of concrete structures

STEEL

TP 3.01 Inspection and Maintenance of Steel Bridge Structures - Towers and Deck Boxes
- TI 3.01.1 Inspection of internal elements of Towers
- TI 3.01.2 Inspection of external elements of Towers
- TI 3.01.3 Inspection of internal elements of Steel Road Girders, Steel Rail Girder and Steel Cross Girders
- TI 3.01.4 Inspection of external elements of Steel Road Girders, Steel Rail Girder and Steel Croos Girders
- TI 3.01.5 Inspection of internal elements of Terminal Structures
- TI 3.01.6 Inspection of external elements of Terminal Structures
- TI 3.01.7 Inspection of transverse support of suspended deck
- TI 3.01.8 Inspection of secondary steel work

TP 3.02 Inspection and Maintenance of Bridge Suspension System
- TI 3.02.1 Inspection of external Main Cable elements
- TI 3.02.2 Inspection of Main Cable elements within Anchorage Chambers

TP 3.03 Inspection and Maintenance of Mechanical Bridge Parts
- TI 3.03.1 Inspection and Maintenance of bearings
- TI 3.03.2 Inspection and Maintenance of expansion joints - Roadway Girder
- TI 3.03.3 Inspection and Maintenance of expansion Joints - Railway Girder
- TI 3.03.4 Inspection and Maintenance of hydraulic buffers
- TI 3.03.5 Inspection and Maintenance of Tuned Mass Dampers - Tower

TP 3.04 Repair and Maintenance of steel structures
- TI 3.04.1 Surface protection of steel
- TI 3.04.2 Cleaning of steel structures

CARRIAGEWAY

TP 4.01 Inspection and Maintenance of Carriageway
- TI 4.01.1 Inspection of Roadway Barriers
- TI 4.01.2 Inspection of Surfacing and Road Marking
- TI 4.01.3 Inspection of Wind Screens
- TI 4.01.4 Inspection of Light Masts
- TI 4.01.5 Inspection of deckings at Service Lane, Cross Overs and Service Areas

TP 4.02 Repair and Maintenance of Surfacing
- TI 4.02.1 Repair of Surfacing. Roadway
- TI 4.02.2 Cleaning of carriageway, expansion joint and drainage system

RAILWAY

TP 5.01 Inspection and Maintenance of Structural Parts on Railway
- TI 5.01.1 Inspection of Surfacing
- TI 5.01.2 Inspection of steel structures for rail fixation and anti-derailment arrangement
- TI 5.01.3 Inspection of Catenary Masts
- TI 5.01.4 Inspection of Platform along railway

TP 5.02 Repair and Maintenance of Surfacing
- TI 5.02.1 Repair of Surfacing. Railway

SECONDARY STRUCTURES

TP 6.01 Inspection and Maintenance of moveable access facilities
- TI 6.01.1 Inspection and maintenance of Tower Gantries and Elevators (Lifts)
- TI 6.01.2 Inspection and Maintenance of Main Cable Carriage and Hanger Basket
- TI 6.01.3 Inspection and Maintenance of Gantries for suspended deck

TP 6.02 Inspection and Maintenance of Dehumidi-fication System
- TI 6.02.1 Inspection and Maintenance of Dehumidifications systems

TECHNOLOGICAL SYSTEMS

TP 7.01 Inspection and Maintenance of SCADA
- TI 7.01.1 Inspection and Maintenance of Control and Monitoring System for Emergency and Maintenance (EMC)
- TI 7.01.2 Inspection and Maintenance of Railway Monitoring System (RM)
- TI 7.01.3 Inspection and Maintenance of Structural Health Monitoring System (SHMS)
- TI 7.01.4 Inspection and Maintenance of Safety and Anti Sabotage System (SSS)
- TI 7.01.5 Inspection and Maintenance of Traffic Mangement System (TMS)
- TI 7.01.6 Inspection and Maintenance of Telecommunication System

TP 7.02 Operation and Maintenance of MMS and sub-systems

TP 7.03 Inspection and Maintenance of Electrical Installations
- TI 7.03.1 TI Inspection and Maintenance of Emergency Lighting
- TI 7.03.2 Inspection and Maintenance of Internal Light
- TI 7.03.3 Inspection and Maintenance of Structural Light
- TI 7.03.4 Inspection and Maintenance of Road Lighting
- TI 7.03.5 Inspection and Maintenance of Navigation Warning Lights
- TI 7.03.6 Inspection and Maintenance of Aircraft Warning Lights
- TI 7.03.7 Inspection and Maintenance of Cable Ways
- TI 7.03.8 Inspection and Maintenance of Distribution Panels
- TI 7.03.9 Inspection and Maintenance of Power Cables

TP 7.04 Inspection and Maintenance of Traffic Signs
- TI 7.04.1 Inspection and Maintenance of Traffic Signs

TP 7.05 Inspection and Maintenance of installations for Water supply
- TI 7.05.1 Inspection and Maintenance of Installations for Water supply

TP 7.06 Inspection and Maintenance of Drainage system
- TI 7.06.1 Inspection and Maintenance of Drainage system

Time for preparation of Technical Procedures and Instructions

		Preparation of TP / TI	
		During Progetto Definitivo in DRAFT	During / after construction
INSPECTION			
TP 1.01	Principal Inspection	X	
TI 1.01.1	Instruction on Reporting	X	
TI 1.01.2	Photo and video registration		X
TP 1.02	Supervision Report for Repair Works		X
CONCRETE			
TP 2.01	Inspection of concrete structures		X
TI 2.01.1	Inspection of piers and tower foundations		X
TI 2.01.2	Inspection of anchor blocks		X
TP 2.02	Repair of concrete structures		X
TI 2.02.1	Repair of concrete structures		X
STEEL			
TP 3.01	Inspection and Maintenance of Steel Bridge Structures - Towers and Deck Boxes	X	
TI 3.01.1	Inspection of internal elements of Towers		X
TI 3.01.2	Inspection of external elements of Towers		X
TI 3.01.3	Inspection of internal elements of Steel Road Girders, Steel Rail Girder and Steel Cross Girders	X	
TI 3.01.4	Inspection of external elements of Steel Road Girders, Steel Rail Girder and Steel Croos Girders	X	
TI 3.01.5	Inspection of internal elements of Terminal Structures		X
TI 3.01.6	Inspection of external elements of Terminal Structures		X
TI 3.01.7	Inspection of transverse support of suspended deck		X
TI 3.01.8	Inspection of secondary steel work		X
TP 3.02	Inspection and Maintenance of Bridge Suspension System	X	
TI 3.02.1	Inspection of external Main Cable elements	X	
TI 3.02.2	Inspection of Main Cable elements within Anchorage Chambers	X	
TP 3.03	Inspection and Maintenance of Mechanical Bridge Parts		X
TI 3.03.1	Inspection and Maintenance of bearings		X
TI 3.03.2	Inspection and Maintenance of expansion joints - Roadway Girder		X
TI 3.03.3	Inspection and Maintenance of expansion Joints - Railway Girder		X
TI 3.03.4	Inspection and Maintenance of hydraulic buffers		X
TI 3.03.5	Inspection and Maintenance of Tuned Mass Dampers - Tower		X
TP 3.04	Repair and Maintenance of steel structures		X
TI 3.04.1	Surface protection of steel		X
TI 3.04.2	Cleaning of steel structures		x
CARRIAGEWAY			
TP 4.01	Inspection and Maintenance of Carriageway		X
TI 4.01.1	Inspection of Roadway Barriers	X	
TI 4.01.2	Inspection of Surfacing and Road Marking		X
TI 4.01.3	Inspection of Wind Screens		X
TI 4.01.4	Inspection of Light Masts		X
TI 4.01.5	Inspection of deckings at Service Lane, Cross Overs and Service Areas		X
TP 4.02	Repair and Maintenance of Surfacing		X
TI 4.02.1	Repair of Surfacing. Roadway		X
TI 4.02.2	Cleaning of carriageway, expansion joint and drainage system		X

		Preparation of TP / TI	
		During Progetto Definitivo in DRAFT	During / after construction
RAILWAY			
TP 5.01	Inspection and Maintenance of Structural Parts on Railway		X
TI 5.01.1	Inspection of Surfacing		X
TI 5.01.2	Inspection of steel structures for rail fixation and anti-derailment arrangement		X
TI 5.01.3	Inspection of Catenary Masts		X
TI 5.01.4	Inspection of Platform along railway		X
TP 5.02	Repair and Maintenance of Surfacing		X
TI 5.02.1	Repair of Surfacing. Railway		X
SECONDARY STRUCTURES			
TP 6.01	Inspection and Maintenance of moveable access facilities		X
TI 6.01.1	Inspection and maintenance of Tower Gantries and Elevators (Lifts)		X
TI 6.01.2	Inspection and Maintenance of Main Cable Carriage and Hanger Basket		X
TI 6.01.3	Inspection and Maintenance of Gantries for suspended deck		X
TP 6.02	Inspection and Maintenance of Dehumidi-fications System		X
TI 6.02.1	Inspection and Maintenance of Dehumidification Systems		X
TECHNOLOGICAL SYSTEMS			
TP 7.01	Inspection and Maintenance of SCADA		X
TI 7.01.1	Inspection and Maintenance of Control and Monitoring System for Emergency and Maintenance (EMC)		X
TI 7.01.2	Inspection and Maintenance of Railway Monitoring System (RM)		X
TI 7.01.3	Inspection and Maintenance of Structural Health Monitoring System (SHMS)		X
TI 7.01.4	Inspection and Maintenance of Safety and Anti Sabotage System (SSS)		X
TI 7.01.5	Inspection and Maintenance of Traffic Mangement System (TMS)		X
TI 7.01.6	Inspection and Maintenance of Telecommunication System		X
TP 7.02	Operation and Maintenance of MMS and sub-systems		X
TP 7.03	Inspection and Maintenance of Electrical Installations		X
TI 7.03.1	TI Inspection and Maintenance of Emergency Lighting		X
TI 7.03.2	Inspection and Maintenance of Internal Light		X
TI 7.03.3	Inspection and Maintenance of Structural Light		X
TI 7.03.4	Inspection and Maintenance of Road Lighting		X
TI 7.03.5	Inspection and Maintenance of Navigation Warning Lights		X
TI 7.03.6	Inspection and Maintenance of Aircraft Warning Lights		X
TI 7.03.7	Inspection and Maintenance of Cable Ways		X
TI 7.03.8	Inspection and Maintenance of Distribution Panels		X
TI 7.03.9	Inspection and Maintenance of Power Cables		X
TP 7.04	Inspection and Maintenance of Traffic Signs		X
TI 7.04.1	Inspection and Maintenance of Traffic Signs		X
TP 7.05	Inspection and Maintenance of installations for Water supply		X
TI 7.05.1	Inspection and Maintenance of Installations for Water supply		X
TP 7.06	Inspection and Maintenance of Drainage system		X
TI 7.06.1	Inspection and Maintenance of Drainage system		X

Appendix 5.11.A - Inspection and Maintenance of Hydraulic Buffers

COWI

Memo

Title: Messina Bridge

O&M Hydraulic buffer systems

Date: 21 May 2010

To

Copy

From

COWI A/S

Parallelvej 2
DK-2800 Kongens Lyngby
Denmark

Tel +45 45 97 22 11
Fax +45 45 97 22 12
www.cowi.com

1 Operation and maintenance - Hydraulic buffer systems

Following items shall, as a minimum, be included in the operation and maintenance manual for of the hydraulic buffer systems:

- Hydraulic concept and principles
- Functioning description for:
  - Hydraulic buffers
  - Control and monitoring systems including data logging
- Layouts
- Description of operation and malfunction messages

2 Inspections/maintenances

This section describes which types of inspections/maintenance are required for the hydraulic buffer systems and how often these are expected to be carried out.

2.1.1 Service inspection

Service inspection shall be carried out every 2 months and includes visual control of the systems by owner's skilled personnel.

2.1.2 Routine inspection/maintenance

Routine inspection/maintenance shall be carried out every half year by the service contractor for hydraulic systems. This includes control of buffers, leakages, oil level, accumulator/system pressure compare to manometer, hoses, pipes, spherical bearings etc.

Oil sample for quality control and new filters every second year etc.

2.1.3 Principal inspection

Principal inspection shall be carried out every year by the consultant and includes control of buffers, leakages, oil level, system pressure, hoses, pipes, spherical bearings etc.

The inspection shall be carried out be engineer with specialty in hydraulic systems. Before inspection the functioning and maintenance manual shall be studied.

2.1.4 Inspection reports
Inspection reports shall be implicated according to approved inspection instruction schedules for hydraulic buffer systems.

All inspection reports shall be controlled by the consultant engineer and returned to owner with comments and potential recommendations for maintenance.

2.2 Spare parts
The Contractor shall include all spare parts and consumables necessary for operation of the hydraulic buffer systems.

2.3 Critical spare parts
The Contractor shall include a list of spare parts supplied for the operation of the hydraulic buffer systems. As a minimum, the Contractor shall supply all spare parts recommended by the manufactures/suppliers for the supplied equipment for the same applications. Manufacture, type and expected life time.

2.3.1 Warranty period
Warranty period 5 years

3 Sequences for replacement and main maintenance activities for hydraulic buffer systems

According to the schedule shown in the report for Life Cycle Cost Study.

Appendix 5.11.B - Inspection and Maintenance of Access Facilities - Moveable

COWI

Memo

	Eurolink, Messina Strait Bridge, Progretto Definitivo
Title	Inspection & Maintenance of Access Facilities
Date	21 May 2010
To	
Copy	
From	

COWI A/S

Parallelvej 2
DK-2800 Kongens Lyngby
Denmark

Tel +45 45 97 22 11
Fax +45 45 97 22 12
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1 Introduction

This memo identifies elements of the access facilities that are proposed to be inspected and maintained at certain intervals to assure what is important to functional and safety operation.

The proposed inspection & maintenance covers the following access facilities:

Access facilities - Moveable

- Gantries for suspended deck
- Gantries for tower
- Lifts
- Main cable carriage & hanger basket

2 Inspection & Maintenances of Access Facilities - Moveable

2.1 Gantries for suspended deck

The inspection of the gantry trolley equipment shall as minimum cover the following check of structural, mechanical and control components:

Check	Interval	Remarks
Structural components (access gantry)		
Check the gantry rails for signs of wearing and corrosion.		
Check the gantry rails fixing and alignment.		
Check the tightness of fixing bolts.		
Check the access gantry structure for signs of wearing, corrosion and thickness of corrosion protection.		

Check	Interval	Remarks
Check welding connections for fatigue cracking by NDE methods.		
Check the structural integrity of all hand rails, stairs, grating, safety barriers and wires.		
Mechanical components (trolley equipment)		
Check the wheels and bearings for signs of corrosion and wearing.		
Check the wheel bearings for lubricant.		Normally life-time lubricated.
Check the tightness of fixing bolts.		
Check conditions of the linear drive motor		
Check the mechanical locking functionality.		
Check the brake for wear of friction linings.		
Check the air gap and adjust if necessary.		
Check conditions of the rive clutch.		
Check the travelling machinery gear for lubricant leakage.		Normally life-time lubricated.
Check conditions of the roller drive pinion.		
Check the travelling motion (acceleration and deceleration).		
Control components		
Check that the frequency converter operates correctly.		
Check linear drive speed control.		

Check	Interval	Remarks
Check dock positional sensor.		
Check positional sensor.		

2.2 Gantries for towers

The inspection of the access cradle equipment shall as minimum cover the following check of structural, mechanical and control components:

Check	Interval	Remarks
Structural components (access cradle)		
Check the tightness of fixing bolts.		
Check the access gantry structure for signs of wearing, corrosion and thickness of corrosion protection.		
Check welding connections for fatigue cracking by NDE methods.		
Check the structural integrity of all hand rails, stairs, grating, safety barriers and wires.		
Mechanical components (electrical powered winches)		
Check the winch drum and bearing for signs of corrosion, wearing, deformation and deterioration.		
Check the winch drum bearing and gearing for lubrication.		
Check the tightness of fixing bolts.		
Check conditions of the linear drive motor		
Check the brake and locking functionality.		
Check the travelling machinery gear for lu-		Normally life-

Check	Interval	Remarks
bricant leakage.		time lubricated.
Check the travelling motion (acceleration and deceleration).		
Check the wire diameter, signs of wear, kinks, broken wires and other deterioration.		
Control components		
Check that the frequency converter operates correctly.		
Check linear drive speed control.		
Check dock positional sensor.		
Check positional sensor.		

2.3 Lifts
The inspection of the lifts equipment shall as minimum cover the following check of structural, mechanical and control components:

See attached checklist paradigm.

2.4 Main cable carriage & hanger basket
The inspection of the main cable carriage and hanger basket equipment shall as minimum cover the following check of structural, mechanical and control components:

Check	Interval	Remarks
Structural components (cable carriage and hanger basket)		
Check the tightness of fixing bolts.		
Check the carriage and basket structures for signs of wearing, corrosion and thickness of corrosion protection.		

Check	**Interval**	**Remarks**
Check welding connections for fatigue cracking by NDE methods.		
Check the structural integrity of all hand rails, stairs, grating, safety barriers and wires.		
Mechanical components (trolleys and diesel generator powered winches)		
Check the wheels and bearings for signs of corrosion and wearing.		
Check the wheel bearings for lubricant.		
Check the winch drum and bearing for signs of corrosion, wearing, deformation and deterioration.		
Check the winch drum bearing and gearing for lubrication.		
Check the tightness of fixing bolts.		
Check conditions of the linear drive motor		
Check the brake and locking functionality.		
Check the travelling machinery gear for lubricant leakage.		Normally lifetime lubricated.
Check the travelling motion (acceleration and deceleration).		
Check the wire diameter, signs of wear, kinks, broken wires and other deterioration.		
Check welded wire fixing elements for fatigue cracking by NDE methods.		

Check	**Interval**	**Remarks**
Control components		
Check that the frequency converter operates correctly.		
Check linear drive speed control.		
Check dock positional sensor.		
Check positional sensor.		

Service and maintenance

e 1

In order to avoid unnecessary breakdowns, those responsible for the service and maintenance of this equipment must regularly ensure that all scheduled maintenance work is carried out at the recommended intervals according to the maintenance program below.

Adjustments and replacement as a result of inspection, must be carried out by trained/authorized service personnel.
Only ALIMAK Genuine Spare Parts must be used.

WARNING !

Unintended operation

Always put the lift's "Normal / Inspection" switch in Inspection position before carrying out any service work.

When leaving the car without having completed the service work or to carry out service, the main switch must be switched off, locked and tagged.

Failure to follow this warning can cause death or personal injury.

Service intervals

Intervals based on operating time shall be followed in the first instance. If the lift is used only periodically, the first applicable interval to be reached shall be followed.

Checklist

Checklist, with room for notes on maintenance executed, will be found at the end of this manual. Use it!

Service and maintenance schedule

See the appendix at the end of this manual for tightening torques.

Interval		Part	Instructions
40 operating hours or at least every 2nd month	1.	Sign plates/ instruction manuals	Check that all signs are in position according to the spare parts manual, and that they are legible. Check also that the documentation according to the documentation box is available.
	2.	Safety device	Check with the user/users if the safety device has been tripping without cause or if noise can be heard from the device during operation. For further details, see the instructions for checking wear on the safety device under the heading "Adjustment and wear limits".
	3.	Gear box	Check the oil level and refill to proper indicated level, if necessary. Leaking seals shall be replaced by trained/authorized service personnel.
	4.	Counter roller(s) at the rear of the gear box and safety brackets and guide rollers on the lift car machinery frame.	Check that all screw joints are properly tightened.

Interval		Part	Instructions
	5.	Attachment of gear box	Check that all screw joints are properly tightened.
	6.	Electric motor motor control and brakes	Check that the car stops within acceptable limits, specified later in this chapter.
	7.	Main switches and emergeny stop switches	Check that all main switches and emergency stop switches are working. Make test runs with each one of the switches in "Off"-position.
	8.	Control	Check that the operation of the control system is correct.
	9.	Brake lining	Check the play between the electro-magnet armature and the rotating brake disc according to instructions later in this chapter. See the special instruction for checking the brake torque with a spring balance – if car stopping positions exceeds stated values.
	10.	Lift cable(s)	Check the cable for wear and to ensure that no kinks occur. Check also the attachment of the cable in the cable support arm on the lift car and the fixture in the lift mast – where a cable guiding device and trolley are furnished.
	11.	Cable basket, where applicable	Clean the cable basket. If the cable guiding device is of a type for power and control cables which has been taped together, check the tape and, if necessary, reinforce it along the entire length of the cable.
	12.	Electrical interlocks	Check all electrical interlocks by making test runs with: a) Car entrance door open. c) With car trap door open. b) Car exit door open. d) Each landing door open. ***The lift must not start. Be sure to check only ONE switch at a time.***
	13.	Mechanical interlocks	Check all mechanical interlocks by making test runs and at the same time try to open the doors. ***Car and landing doors must remain locked until the car stops at the landing.***
	14.	Car floor / roof	Clean the car floor and roof.
	15.	Lubricating	See the instructions in the "Lubrication diagram". Also check rack for possible damages, misalignment and attachment, when lubricating.
120 operating hours or at least every 6 months	20.	Rack	Retorque rack bolts to 185 Nm **(137 lbf x ft)** after 120 hours of initial operation and then once a year.
	21.	Lift mast	Check by striking them that all screw joints of all racks and mast joints are properly tightened. Also check the screw joints for attaching the mast in the base frame.
	22.	Mast ties	Check that all screw joints in all mast ties are properly tightened. Also check attachment to structure.
	23.	Limit switches and cams, and final limit switch with associated cams	Check attachment and function. Check function by making test runs. Loosen the attachment of the Up and Down limit switches from the machinery plate (alternatively make jumpers for these switches in the electrical panel) and check the final limit switch correspondingly.
	24.	Cable guides	Check the cable guides with regard to attachment, function and installation in the mast in relation to the cable support arm on the lift car.
	25.	Cable trolley, where applicable	Check that the cable trolley does not come in contact with the buffer frame at the ground landing and that the trolley is parallel to the mast tubes. Check the function, attachment and wear on the guide and cable rollers and that the cable wheel on the trolley runs smoothly. See also special instruction for checking the trolley's guide roller play.

Interval	Part	Instructions
	26. Base slab/pit	Remove all debris, which may have fallen on/into the base (or pit).
	27. Buffers for lift	Check that the buffers are in position and in a proper condition.
	28. Car and landing doors	Check the function, attachment and wear on the doors. Clean guides from dust and debris.
	29. Signal equipment and lighting	Check the function of the alarm signal, lighting and, where applicable, voice communication system.
	30. Emergency lighting	Switch off the main ON/OFF switch on the car roof and check to ensure that the emergency light functions. Switch on the main ON/OFF switch and check that the LED on the battery charger is lighted.
	31. Rack and pinion	Check the wear on the rack and pinion according to the instructions under the heading "Adjustment and wear limits".
	32. Enclosures	Check that there is nothing in the vicinity of the landing which can be used as a ladder or can reduce the correct height of the enclosure in any way. Point out any infringements and risks of injuries to the site manager.
	33. Scaffolding adjacent to lift	Check that the distance from the lift car to landings, scaffolding, balconies, windows or any other location where persons may find themselves, are not less than regulations dictate. Point out any infringements and risks of injuries to the site manager.
	34. Rollers and roller assemblies	Check wear and bearing play of the lift car guide rollers. Adjustment and replacement, when required shall be carried out by trained/authorized service personnel.
	35. Safety device	Test the safety device according to the instructions under the heading "Drop test".
	36. Emergency lowering	Check by test that the emergency lowering device works properly and that the handle is fully reset after operation.
	37. Electric motor(s)	If necessary, clean the cooling flanges of the electric motor(s).
	38. Overload sensing system – where applicable	Overload test to probe overload sensing system. Prevent sparks with grease from the overload sensing pull rods and cup springs.
	39. Lubricating	See the instructions in the "Lubrication diagram".
1000 operating hours or at least once a year	50. Electric wiring	Check all wires, sealing glands and connections.
	51. Motor overload protector	Check that the motor overload protector is set with the rated current on the data plate for the electric motor.
	53. Deformations/ mechanical damage	Inspect the equipment visually in its entirety for deformation/mechanical damage to mast tubes/beams, diagonal ties in the mast sections, mast ties, doors, protective rails, floors, etc. This inspection and any actions which may be necessary after the inspection must be performed by trained/authorized service personnel.
	53. Corrosion, damage and wear	Inspect the equipment in its entirety for corrosion and wear on loadbearing and force-absorbing components by the aid of an ultrasonic thickness measuring instrument. This inspection and any actions which may need to be taken after the inspection must be performed by trained/authorized service personnel.

Interval	Part	Instructions
	54. Lift mast/ guide rail	Check that all screw joints of all racks and mast joints are properly tightened. Also check the screw joints for attaching the mast in the base.
	55. Centrifugal brake	Inspect centrifugal brake and brake lining according to the instructions under heading adjustment and wear limits; "Centrifugal brake".
2000 operating hours or at least every 2 year	58. Pinion and counter roller on drive unit	Dismount and lift out the motor/gear unit from the machinery plate to be able to make a precise check of the pinion and its counter roller. Dismantling is not necessary if enough clearance is available between the machinery and the building structure.
	59. Lubricating	See the instructions in the "Lubrication diagram".
	60. Centrifugal brake	Dismantle the brake motor from the centrifugal brake and inspect the brake hub with linings. See the instructions in the under heading "Centrifugal brake".
	61. Corrosion protection devices	Replace the corrosion protection devices which are located inside the electrical panels according to the following: Main panel (M-panel) 2 pcs. P/N 3002 301-105 Car top control panel (VFC) 2 pcs. P/N 3002 301-105 Car top control panel (DOL) 1 pcs. P/N 3002 301-101 Base panel (B-panel) 1 pcs. P/N 3002 301-105 Landing control stations 1 pcs. P/N 3002 301-101
	62. Battery for emergency light	Replace the battery with new fully charged battery.
Every 4th year or according to sign on the safety device	63. Safety device	Replace the complete safety device.

Appendix 5.11.C - Inspection and Maintenance of Dehumidification Systems

COWI

Memo Messina Bridge

Title O&M Dehumidification systems

Date 21 May 2010

To MJU

Copy

From EIS

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1 Operation and maintenance - Dehumidification systems

Following items shall, as a minimum, be included in the operation and maintenance manual for of the dehumidification systems:

- Dehumidification concept and principles
- Functioning description for:
  - Dehumidification plants including operation set points
  - Ventilation systems
  - Control and monitoring systems including data logging
- Layouts
- Description of operation and malfunction messages

2 Inspections/maintenances

This section describes which types of inspections/maintenance are required for the dehumidification systems and how often these are expected to be carried out.

2.1.1 Service inspection

Service inspection shall be carried out every 2 months and includes visual control of the systems by owner's skilled personnel.

2.1.2 Routine inspection/maintenance

Routine inspection/maintenance shall be carried out every year by the service contractor for dehumidification, ventilation and automatic suppliers of the systems. This includes control of operation data, calibration of hygrostats, control measurements of unit capacities, functioning of dampers, regeneration temperature of dehumidification units, potential mechanical damages of fans og flexible connections, potential loose duct connections, defect supports and attachments, filter pressure drop, signal lamps in control panel etc.

2.1.3 Principal inspection

Principal inspection shall be carried out every fifth year by the consultant and includes control and calibration of hygrostats, control measurements of unit capacities, control of drive belts (recirculation fans and dehumidifiers), wearing of dampers, filter control, signal lamps in control panel etc.

The inspection shall be carried out be engineer with specialty in dehumidification systems. Before inspection the functioning and maintenance manual shall be studied.

2.1.4 Inspection reports

Inspection reports shall be implicated according to approved inspection instruction schedules one for each field, dehumidification, ventilation and automatic systems.

All inspection reports shall be controlled by the consultant engineer and returned to owner with comments and potential recommendations for maintenance.

2.2 Spare parts

The Contractor shall include all spare parts and consumables necessary for operation of the dehumidification systems.

2.3 Critical spare parts

The Contractor shall include a list of spare parts supplied for the operation of the dehumidification systems. As a minimum, the Contractor shall supply all spare parts recommended by the manufactures/suppliers for the supplied equipment for the same applications. Manufacture, type and expected life time.

2.3.1 Warranty period

Warranty period 5 years

3 Replacement sequences for dehumidification systems

New plants	25 years
Recirculation fans	25 years
Motorized dampers	15 years
Instruments	15 years

Appendix 10.2.A - Performance Log. Moveable access facilities

Inspection and Maintenance
Performance Log - Costs and spent time for all activitities

Level 2	Level 3	Level 4	Level 5	Project ID	Hierarchy element	Work order no.	Costs	Activity	Activity period	Remarks
									mm.yy - m'm'.y'y'	
1				P	Suspension Bridge					
	3			SS	Secondary System					
		1		R4	Secondary Structures					
			7	PA	Tower Gantries and Elevators					
			8	?	Main Cables Carriages and Hanger Baskets					
			9	?	Gantries for Suspended Deck					

The activity should be chosen from the following list:	Abbreviation for activity:
Statutory inspection and maintenance works (of the facility)	Stat. inspec/maint.
Inspection (of the facility)	Inspec.
Maintenance work (of the facility)	Maint.
Preparation for operation of the facilty (for inspection and/or maintenance works on the bridge)	Prep.
Operation of the facility (when inspecting and/or maintaining the bridge)	Oper.

The elements at level 5 is subdivided in elements at level 6, as shown below

Level 2	Level 3	Level 4	Level 5	Level 6	Project ID	Hierarchy element	Work order no.	Costs	Activity	Activity period	Remarks
										mm.yy - m'm'.y'y'	
1					P	Suspension Bridge					
	3				SS	Secondary System					
		1			R4	Secondary Structures					
			7		PA	Tower Gantries and Elevators					
				1	?	Tower Gantries, Sicily Tower					
				2	?	Tower Gantries, Calabria Tower					
				3	?	Elevators, Sicily Tower					
				4	?	Elevators, Calabria Tower					
			8		?	Main Cables Carriage and Hanger Basket					
			9		?	Gantries for Suspended Deck					
				1	?	Gantry for side span - Sicily					
				2	?	Gantry for main span - Sicily					
				3	?	Gantry for main span - Calabria					
				4	?	Gantry for side span - Calabria					

Appendix 11.1.A - Inspection Programme

STRUCTURAL STEELWORK INSPECTIONS
6 YEAR CYCLE
RESOURCE ESTIMATION

Routine Superficial - 3 months until first PI	(blue)
Routine General - 2 year cycle	(orange)
Principal Inspection - 6 year cycle	(yellow)
Special Inspections - assume Avge 1 man per month.	(green)
Special Inspections derived from RBI	(light blue)

			Year 1																								**Year 3**																								**Year 5**																							
															Year 2																								**Year 4**																								**Year 6**											
Main Cable	West side				1			1						1			1			1			8			1			1			1									1						8						1												1						12	12	4	
External	East side											8																									12	12	4																								8															
Main Cable	West side																						4																								4																								4			
Internal	East side											4																									4																								4															
Tower Sicily	Internal								6																								6	6																										6																		
	External							1																								12																									1																			
Tower Calabria	Internal																				6																										6																								6	6				
	External																			1																										1																								12						
Deck Boxes	Internal - GI and PI spread over 6 yr cycle.				5	4											5	4											5	4											5	4											5	4											5	4								
Deck Boxes	External - GI and PI spread over 6 yr cycle.		5	4											5	4											5	4											5	4											5	4											5	4										
Deck Boxes	Special areas - GI and PI spread over 6 yr cycle.						4	3											4	3											4	3											4	3											4	3											4	3						
Special Inspect	Structural - allow 1 man week per month Avge						3			3		3		3					3			3		3		3					3						3	3					3			3		3	3	3					3			3		3	3	3					3						3	3
	i.e. allow average of 3 man weeks per quarter																																																																											
Special Inspect	Derived from Reliability Based Inspection analysis																																																																			2	2				
	Allow 4 man weeks in year 6.for paint																																																																									
		Avge																																																																								
	Man weeks per month Inspectors	6	5	4	6	4	7	5	6	3	12	3	0	4	5	4	6	4	7	5	6	3	12	3	0	4	5	4	6	4	7	16	6	6	16	12	7	3	5	4	6	4	7	4	6	3	12	3	3	3	5	4	6	4	7	4	6	3	12	3	3	3	5	4	6	4	7	15	8	8	16	12	7	3

STRUCTURAL STEELWORK INSPECTIONS						
6 YEAR CYCLE					Assume 4 days inspecting plus one writing per week.	
RESOURCE ESTIMATION					Assume 40 effective working weeks per year per inspector.	
					Inspection times include for inspection of fixed access stairs, ladders and platforms.	
					Internal Steel surfaces are painted.	
Main Cable	West side and	Routine Superficial - 3 months		2 men 2 days for both sides		
External	East side	Routine General - 2 years		4 men for 2 weeks for one side	say 166 clamps on one side with 2 men doing 12 perday. 4 man gang take say 7 days.	
		Principal Inspection - 6 years		4 men for 7 weeks	4 men for 6 weeks for one side plus 1 week for tower top saddles etc.	
Main Cable	West Side and	Routine General - 2 years		4 men for 1 week for one side		
Internal	East Side	Principal Inspection - 6 years		4 men for 1 week for one side		
Tower Sicily	Internal	Routine General - 2 years		2 men 3 weeks	20 sections per leg, each c 20m - 1 man 2 section per day plus 1 manday per c/b.	10+10+3 man days = say 6 man weeks
		Principal Inspection - 6 years		2 men 6 weeks	Assume PI takes twice time.	
	External	Routine General - 2 years		2 Men 1/2 week		
		Principal Inspection - 6 years		4 men 3 weeks	Allow 1 gang week per leg plus 1 gang week for three crossbeams.	
Tower Calabria	Internal	Routine General - 2 years		2 men 3 weeks	20 sections per leg, each c 20m - 1 man 2 section per day plus 1 manday per c/b.	10+10+3 man days = say 6 man weeks
		Principal Inspection - 6 years		2 men 6 weeks	Assume PI takes twice time.	
	External	Routine General - 2 years		2 Men 1/2 week		
		Principal Inspection - 6 years		4 men 3 weeks	Allow 1 gang week per leg plus 1 gang week for three crossbeams.	
Deck Boxes	Internal	Routine General - 2 years		4 men 2½ weeks	Say 120 crossbeams - gang of 4 do 12 per day plus boxes.	10 gang days @ 4 days per week.
General		Principal Inspection - 6 years		4 men 5 weeks	Assume PI takes twice time.	
					Average per annum = 5 man weeks GI and 4 man weeks on PI.	
Deck Boxes	External	Routine General - 2 years		4 men 2½ weeks	Say 120 crossbeams - gang of 4 do 12 per day.	10 gang days @ 4 days per week.
General		Principal Inspection - 6 years		4 men 5 weeks	Assume PI takes twice time.	
					Average per annum = 5 man weeks GI and 4 man weeks on PI.	
Deck Boxes	All	Routine General - 2 years		4 men 2 weeks	Allow 4 man gang 2 weeks for special areas, e.g. crossovers, expansion boxes, bearings.	
Special areas		Principal Inspection - 6 years		4 men 4 weeks	Assume PI takes twice time.	
					Average per annum = 4 man weeks GI and 3 man weeks on PI.	
Special Inspections	All	Ad hoc inspections as required.			Structural - allow 1 man week per month Avge	
					i.e. allow average of 3 man weeks per quarter	
Special Inspections	RBI	Defined scope Special Inspections		Allow 4 man weeks in year 6.	Derived from Reliability Based Inspection analysis - external paint system.	

Appendix 11.2.A - Maintenance Programme

Maintenance Programme

			Years after completion of Messina Strait Bridge																																																										
Structure	**Element no.**	**Description of maintenance work**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Towers	1.2.1	Outer surface, total new top coat																														■																														■
Roadway Girder, direction Sicily	1.2.2.1	Outer surface, total new top coat																														■																														■
Roadway Girder, direction Calabria	1.2.2.2	Outer surface, total new top coat																														■																														■
Steel Girder, railway	1.2.2.1	Outer surface, total new top coat																														■																														■
		Upper surface, local repairs of surfacing															■										■																				■										■					
		Upper surface, replacement of surfacing																															■																													
Cross Girders	1.2.3.4	Outer surface, total new top coat																														■																														■
Expansion Joints, Roadway	1.3.2.2.1 - 2	Replacement of wearing parts																					■																				■																			
		Total replacement																																																			■									
Expansion Joints, Railway	1.3.2.2.3	Replacement of wearing parts																					■																				■																			
Hydraulic buffers	1.3.2.3	Maintenance of hydraulic sstems						■												■												■												■												■						
		Maintenance incl. oil analysis and N2 control												■																																				■												
		Maintenance incl. replacement of hoses, oil and N2 control																								■																																				
		Maintenance incl. replacement of hoses, oil, sealings and valves and N2 control																																				■															■									
Main Suspension cables	1.2.2.4	Caulking replacement																■															■															■														■
		Replacement of elastomeric wrap																															■																													■
		Opening of main cable for inspection																															■																													■
Cable Clamps	1.2.2.1	Total new top coat																■															■															■														
Carriageway surfacing	1.3.3.1	Maintenance surfacing and road marking											■					■																				■																■					■			
		Replacement of surfacing in slow lanes and local repairs																					■											■																												
		Total replacement of surfacing and road marking																																									■																			
Roadway Barriers	1.3.1.3	Replacement of galvanisation																																																	■										
Wind Screens	1.3.1.2	Replacement of galvanisation																																																	■										
Dehumidification plant	1.3.1.10	New plant for main cables																										■																									■									
Railway Track system		Ultrasonic testing		■		■		■		■		■		■		■		■		■		■			■		■		■		■		■		■		■		■		■				■		■		■		■		■		■		■		■		■	
		Rail grinding						■					■					■										■					■					■										■					■					■				
		Replacement of rails																					■																				■																			

Appendix 12.5.A - Inspection of Fire Hydrant and Washing System

COWI

Memo	Messina Strait Bridge	
Title	Inspection and maintenance	
Date	20 May 2010 Revision: 01-02-2011/MF	
To	MJU	
Copy		
From	KPL	

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1 Purpose

The purpose of memo is to give an overview for expected operation and maintenance procedures for the mechanical systems:

- Drainage of bridge girders
- Fire hydrant system and washing system

2 Drainage of bridge girders

2.1 System layout

To collect rain water on bridge decks a gravity drain water pipe system will be installed inside the bridge girders.

The rain water will be lead on shore for cleaning before discharge to the Messina Strait.

Rain water gullies will be located at intervals along the emergency lane on the roadway girders.

Rain water gullies will be located along both sides of the railway girder.

The discharge arrangement at the Sicilian and Calabria side will consist of sedimentation reservoirs and oil separator. No further cleaning is foreseen.

2.2 Inspection and maintenance overview

Following inspection and maintenance works for the drain system can be assessed:

2.2.1 Gravity pipes

To prevent clogging of pipes due to a slowly build up of sedimentation the pipes shall be inspected frequently.

The gravity pipes are designed for self cleaning during normal operation but the possible ingress of foreign bodies such as cigarette packages, trash of all kinds. must be followed.

Due to experience obtained can flushing of pipes with high pressure water be a consequence of the observations. Water will be available on the bridge for the purpose.

2.2.2 Discharge arrangement
The Sedimentation reservoir and the Oil and Petrol interceptor must be emptied regularly.

Clean up works, which often is carried out by service contractors having special equipment and experience for mud- and oil pumping.

3 Fire hydrant system and washing system

3.1 System layout
The system consists of two separate systems:

- The fire hydrant system
- The utility water system (the washing system)

Two similar pump installations are located at each tower. The pump installations include water tanks, fire pump installations and utility water pump installations.

The fire pumps supply water to the entire bridge in fire mains located at the railway girder. Further will the pumps supply water to the fire risers inside the tower. The utility water pumps supply utility water to the entire bridge as well as to the risers inside the towers.

The fire mains are connected to fire hydrants located at intervals throughout the bridge and inside the towers.

The utility water mains are connected to wash valves located at intervals throughout the bridge and inside the towers. Each pipe connection on bridge for fire hydrants and wash valves will be frost protected by means of electrical heat tracing and insulation. Water will flow in the mains in case of low temperature (freezing risk).

3.2 Inspection and testing overview
It shall be noted that specific requirements as regard operation and maintenance from fire authorities at the Messina Bridge are not yet incorporated.

This section provides a summary of the minimum requirements for the routine inspection, testing, and maintenance of the fire hydrant system and utility water system.

3.2.1 Fire and utility water main

Item	Frequency	Maintenance activity

Item	Frequency	Maintenance activity
Inspection		
Valves	Weekly (in fire system) Monthly (in utility system)	• In the normal open or closed position • Properly sealed, locked • Accessible • Provided with appropri-ated wrenches • Free from external leaks • Provided with appropri-ated identification
Piping	Annually	Visually
Fire hydrant (Hose connec-tions)	Annually	• The hand wheel is not broken or missing • The outlet hose treads are not damaged • No leaks are present • The reducer and the cap are not missing
Insulation (Frost protection)	Annually	Visually
Test		
Control valves	Annually	• Position • Operation • Supervisory signals
Pressure control valve	5 years	• Flow test (adjustment to be made in accordance with the manufacture's instruction)
Pressure reducing valves	5 years	• Downstream pressure are maintained in ac-cordance with the de-sign criteria • The supply pressure is in accordance with the design criteria • The valve are not leak-ing • Valve and trim are in good condition

Item	Frequency	Maintenance activity
Hydrostatic test	5 years	Hydrostatic test of not less than 2 hours.
Flow test	5 years	A flow test to be conducted at the hydraulic most remote fire hydrant /wash valve to verify the water supply still provides the design pressure at the required flow.
Maintenance		
Fire hydrants	Annually	Fire hydrantsthat do not operate smoothly or open fully shall be lubricated, repaired, or replaced.
Valves (all types)	Annually/as needed	According to supplier recommendations

3.2.2 Fire an utility water pumps

Item	Frequency	Reference
Inspection		
Fire pump system Utility water pump system	Weekly Monthly	The purpose of inspection shall be to verify that the pump assembly appears to be in operating condition and is free from physical damage.
Test		
Fire pump operation (No-flow condition)	Weekly	Starting of fire pump assemblies (running for 10 minutes)
Flow condition (all pumps)	Annually	An annual test of each pump assembly shall be conducted under minimum, rated, and peak flows of the fire pump by controlling the quantity of water discharged through approved test devices.
Maintenance		

Item	Frequency	Reference
Pump systems	Annually	A preventive maintenance program shall be established on all components of the pump assembly in accordance with the manufacturer's recommendations.
Mechanical transmission	Annually	As above
Electrical system	Varies	As above
Controller, various components	Varies	As above

3.2.3 Water storage tanks

Item	Frequency	Reference
Inspection		
Water level alarms	Quarterly	Visual
Interior	5 years	Visual
Test		
Level indicators	5 years	Test for accuracy and freedom of movement.
Pressure gauges	5 years	Test with a calibrated gauge in accordance with the manufacturer's instructions. Gauges not accurate to within 3 percent of the scale of the gauge being tested shall be recalibrated or replaced.
Maintenance		
Drain silt	Semi-annually	Silt shall be removed during interior inspections or more frequently as needed to avoid accumulation to the level of the tank outlet.