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EurolinK

# PONTE SULLO STRETTO DI MESSINA

## PROGETTO DEFINITIVO


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# 1 Introduction

## 1.1 The Project

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

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

## 1.2 Scope

This performance specification specifies the requirements for the design, manufacture, installation and testing of the four rail expansion joints to each track at the Messina Bridge. The four locations are:

- Calabria approach spans/terminal structure (E7);
- Terminal structure/suspension bridge (E4);
- Suspension bridge/terminal structure on Sicily (E4);
- Terminal structure/approach spans Sicily (E5).

The scope of works can be summarized as follows:

- Design: detailed design of the railway expansion joints and appurtenant parts, including the submission of design calculations, shop and installation drawings and details to the supervision.
- Manufacture and testing: manufacture, assembly, works inspection and prototype trials under simulated running conditions; dismantling, inspection and re-inspection of the prototype.
- Installation and trial running: installation on the Messina Bridge, connection to running tracks, site trials and adjustments.
- Post-installation: provision of spare parts, operation and maintenance instructions, as built records, and personnel training.

In the reference drawings the arrangement of expansion joints has been shown only in principle. The tender drawings show a specific make of joint, however other makes may be proposed. In such cases the tender drawings may be subject to modifications.

## 1.3 References

### 1.3.1 Design Specifications

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

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

3 CG.10.00-P-RG-D-P-GE-00-00-00-00-00-02-A - “Design Basis, Structural, Annex,” COWI 2010

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

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

### 1.3.2 Material specifications

6 EN ISO 12944:2000. Paints and varnishes - Corrosion protection of steel structures by protective paint systems

7 EN 13674-1:2003. Railway applications - Track - Rail - Part 1: Vignole railway rails 46 kg/m and above

8 EN 13481-5:2002. Railway applications - Track - Performance requirements for fastening systems - Part 5: Fastening systems for slab track

9 EN 10025-1:2004 Hot-rolled products of structural steels

10 EN 10164:1993 Steel products with improved deformation properties perpendicular to the surface of the product – Technical delivery conditions.

11 EN ISO 898-1:2001 Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs (ISO 898-1:1999).

12 EN 20898-2:1994 Mechanical properties of fasteners – Part 2: Nuts with special proof load values – coarse thread (ISO 898-2:1992).

13 UNI EN 14399-3:2005 High-strength structural bolting assemblies for preloading - Part 3: System HR - Hexagon bolt and nut assemblies

14 EN ISO 14555:1998 Welding-Arc stud welding of metallic materials.

### 1.3.3 Drawings

15 GC10.00-P-DX-D-P-SS-A0-GE-00-00-00-01-A. Articulation system - Expansion joints, Overview

16 GC10.00-P-DX-D-P-SS-A0-AP-00-00-00-01-A. Articulation system - Bridge Bearings, Overview

# 2 Nomenclature

The following definitions shall apply:

- "Primary bridge structure" - structural load carrying elements of the suspension bridge part or the terminal structure of the Messina Bridge.
- "Railway expansion joint" - comprises rail assemblies and rail supporting structures and rail dilatation joints.
- "Rail assembly" - in a railway expansion joint, the assembly of running rails, guard rails, rail fastenings, base plates and base plate fastenings.
- "Rail supporting structure" - in a railway expansion joint, the structure which provides direct support to the rail assembly and transfers loads to the primary bridge structure. This shall include any fixing and/or bearings required to locate and articulate the railway expansion joint.
- "Rail dilatation joint"- The joint in the rails, where the rail can absorb movements.
- "Loads" - external forces applied to the railway expansion joint, and imposed deformations such as those caused by restraint of movement due to changes in temperature, or by rotations and movement arising from deformation of the primary bridge structure.

# 3 Design by manufacturer

## 3.1 Design principles and performance objectives

1 The railway expansion joint design, that the manufacturer propose, shall have been used for large movements and under similar conditions with satisfactory results for a period of at least 5 years. It is of importance that the joint type has demonstrated satisfactory results under similar extreme wear conditions as specified for this bridge. The manufacturer shall submit reference list for the proposed expansion joints.

2 The railway expansion joints shall be designed so as to ensure that the rotational, longitudinal or other movements of the bridge deck arising from superimposed loads, weather conditions, temperature change or any other cause, all as calculated from the design criteria set out herein and in the design specifications stated in section 1.3.1 shall be accommodated so as not to adversely affect the safety, comfort or frequency of normal railway operations.

3 Provision must be made to accommodate the relative movement between rail on the transition girder and rail on the main deck. Should the manufacturer's design require the incorporation of adjustment switches, the manufacturer shall design, supply and install such adjustment switches as part of the scope of work. It is also intended that re-railing devices will be located immediately to the landward of each railway expansion joint and as close as practicable to the landward end of the continuous guard rail. The manufacturer shall take account of these features and shall stipulate any requirements to be placed on the adjustment switch or re-railer design or construction in order to ensure that the railway expansion joints achieve their specified design and performance criteria.

4 Normal railway operations, for which the railway expansion joints shall be designed, shall include the possibility of trains on either track being operated in reverse direction and of trains approaching or passing each other at the location of the railway expansion joints or with one at the railway expansion joint while the other is at the most adverse position for movement of the primary bridge structure.

5 The rail supporting structure shall have a design life of 200 years save that any wearing components including bearings and fixings shall be designed for a service life to first major maintenance of minimum 15 years. The rail assembly shall be designed, manufactured and installed to the specified performance requirements for a service life, with normal maintenance, of not less than 15 years to track replacement.

6 The design, manufacture and installation shall ensure that excessive wear of components of the rail assembly due to fretting (repeated, small amplitude movements) does not occur. The service life for the rail assembly stated above shall apply in this respect. Contact stresses, materials, surface finishes and lubrication requirements shall be defined for each sliding surface. For design purposes, a cumulative longitudinal movement at rail level as stated in Table 1 per year (average over the first 15 years) may be assumed.

7 The maintenance requirements for the railway expansion joints shall not interfere with normal railway operations. Normal railway operations will be considered to be adversely affected if the normal maintenance possessions by the railway operator are insufficient to carry out the maintenance required to the railway expansion joint to ensure its continued use at the planned frequency, capacity and speed of the trains having the characteristics of the intended railway stock, due either to excessive wear or breakdown, or inadequate provision

for access to or replacement of the railway expansion joints or their component parts. (Normal maintenance possessions shall be the routine possessions for normal track maintenance which do not affect the scheduled running of trains, and shall additionally include the possession required to replace track at the end of the required track life.)

8 Compatibility of maintenance provisions for the rail assemblies with the track work on the Messina Bridge shall be ensured wherever possible.

9 It shall be an overriding performance requirement that the railway expansion joints shall be designed, manufactured and installed to the satisfaction of the railway authority.

10 The line must concord with the requirement of the category II of the TSI for high speed (lines specially adapted for high speed) of the order V=200km/h, however the design speed is limited to 120 km/h.

## 3.2 Loads

- The loadings for railway expansion joints shall be those defined in [4] section 5. In addition, loads arising from the operational characteristics of the railway expansion joint shall be considered and shall be treated as secondary live loads.
- The partial load factors and load combinations for use in the design of railway expansion joints shall be as given in [4] section 6.
- Impact factors for use on loads on the Railway expansion joint are stated in [5] section 10.5 and 10.8.

## 3.3 Movements and rotations of the primary bridge structure

- The railway expansion joints will be subjected to movements and rotations arising from deformation of the primary bridge structure. The railway expansion joints shall be designed to accommodate values of longitudinal and transverse movement and of angular rotation of up to those given in [15].
- The railway expansion joints shall be designed to accommodate incremental movements and accelerations due to rail live loading, occurring during the passage of a train traveling. The values to be adopted in the design are given in Table 1.

| | Joint type and location | |
|---|---|---|
| | Approach span/Terminal Structure<br>E5 and E7 | Terminal Structure/ Suspension bridge<br>E4 |
| Accumulated movement pr. year | 0.1-1 km | 1- 10 km |
| Expected max. velocity of frequent movement | <1 mm /sec | ~20 mm/sec |
| Expected acceleration of frequent movement | <20 mm/sec$^2$ | ~20 mm/sec$^2$ |

*Table 1: Estimate of accumulated movement pr. year, velocity and acceleration of expansion joints movements*

## 3.4 Performance relating to railway usage

Please refer to [3] section 4.3.1.

## 3.5 Applicability

Maximum vertical and horizontal accelerations shall be evaluated for the various conditions that apply throughout the life of the railway expansion joints, including, as appropriate, the conditions at the limit of serviceability of the various components.

## 3.6 Existing geometry

The railway expansion joint shall be fully compatible with the geometry (under permanent load and mean temperature) and structural arrangement of the primary bridge structure and with the geometry of the adjacent track work.

## 3.7 Clearances

The design shall ensure that no part of the railway expansion joint, except for guard rails, projects above rail level.

## 3.8 Rail fastenings and support

- The running rails shall be supported throughout the length of the railway expansion joint by such means and at such intervals as are necessary to comply with the requirements of this section in respect of rail movements, deflections, twist and stresses under all static and dynamic loadings.
- Rail fastenings on the railway expansion joints shall be the elastic type and the spring element shall exert sufficient force on the foot of the rail to prevent any uplift of the rail relative to the fastening assembly. The assembly shall also prevent lateral movement of the rail relative to the fastening assembly.
- The resilience of the fastenings shall be similar to the one of the used on the main bridge.
- The fastening system shall prevent permanent longitudinal creep of the rails relative to the railway expansion joint structure under braking and traction forces.
- Where angular rotations are accommodated, the fastenings may permit longitudinal movement of rails relative to the fastening assemblies, but at no time shall the axial stresses in the rails be allowed to exceed 50 $N/mm^2$.
- The rollover of the rail head under any combination of vertical and lateral forces specified shall not exceed 1.5 mm.
- Under SLS track forces specified (not derailment or overturning conditions), track gauge under load shall not increase by more than 4 mm from the unloaded condition, measured 14 mm beneath the plane of the rails.
- Local rail deflections shall be limited so that the requirements of section 3.4 for maximum vertical accelerations are complied with. The dynamic behavior of the rails under moving wheel loads shall be taken into account in assessing the vertical accelerations.
- Rail stresses shall be within permissible limits, as determined by established methods, under all static, dynamic and fatigue loadings.
- Detailing of sliding parts shall be such as to minimize the ingress of objects, dirt and contaminants and to ensure the proper functioning of the joint.

- All connections on the rail assembly shall be located and detailed so that inspection, adjustment and maintenance can be easily carried out without removing other components.
- The overall resilience of the rail support system shall be designed to minimize the likelihood of rail corrugations occurring in service, assuming reasonable and regular maintenance of rails and rolling stock.
- The arrangement of the railway expansion joint shall be so as to minimize the noise generated by the joint.

## 3.9 Guard rails

1 Throughout the railway expansion joints, including supplementary provisions for rail movement, through to the track work of the bridge structure, but except as provided in section 3.9(2), continuous guard rails (which may be placed inside or outside the running rails) shall be provided to prevent derailment. The location of the guard rails shall be such that they do not touch the wheel of any train whilst the train is running normally. The location of the controlling faces of the guard rail shall be compatible with the location of the controlling faces of the guard rail on the bridge structure, and also with the controlling features of the re-railers described in section 3.1(3).

2 At any location in the railway expansion joint where the effective track gauge exceeds 1464mm for a length greater than 300mm, the guard rail referred to in section 3.9(1) shall be replaced by an operational check rail that will prevent lateral movement of the wheel sets by more than 5mm from the position that would be adopted by the wheel set positioned centrally within a track having a gauge of 1435mm and with the axle perpendicular to the running rails.

3 The transition between check rail and guard rail shall not leave the wheels unguarded at any point, and the flare through the transition shall be at a rate not steeper than 1 in 150. In the event that any section of the guard rail described in section 3.9(1) is placed outside the rail, overlaps shall be provided where an inside guard rail changes to an outside rail, or where an outside guard rail changes to an operational check rail, to ensure continuous protection.

4 The operational side of the head of inside guard rails shall be vertical. The upper surface of the head of such rails shall be up to 30 mm above the plane of the running rails when new and unworn.

5 Outside guard rails shall be designed to provide protection against derailment equivalent to that provided by inner guard rails.

6 Guard rails, check rails and their supports shall be designed so that they will remain serviceable under a lateral load of 1.2 times the maximum static axle load on the rails applied to the head of the check rail at the most unfavorable location.

## 3.10 Wheel unloading

The action of the railway expansion joint shall ensure that the wheels of a train are continuously supported throughout its length and through the transition to the adjoining track work and that under the worst conditions of negative rotation wheel unloading shall not exceed 20% of the static axle load.

## 3.11 Noise and vibration

The manufacturer shall provide adequate resilience for the rail support to minimize the emission of noise and vibration.

## 3.12 Electrical continuity and stray current protection

- The running rails across the railway expansion joint shall be made electrically continuous with the adjoining track work by the use of insulated bonding cables to ensure no interruption in track circuiting nor of traction current return.
- Appropriate precautions to eliminate stray current corrosion shall be incorporated. The rail support structure shall be electrically continuous with the bridge deck structure or otherwise interconnected with the stray current return system provided for the deck structure.
- The design shall ensure that water, arising from any source, cannot accumulate or stand in the vicinity of the rails.

## 3.13 Access

The design shall facilitate easy access to the whole of the railway expansion joint.

# 4 Materials and workmanship

## 4.1 General

- All materials shall be chemically, structurally and mechanically compatible with the materials specified for the works designed by the supervision. Wherever any such incompatibility could deleteriously affect the life, maintenance or operating efficiency of the works designed by the supervision, appropriate protective or isolation measures shall be included in the design wherever such compatibility would not otherwise be achieved.
- The surface treatment shall meet the requirements of corrosively category C5-M according to [6].
- High performance sliding materials with increased load capacity and durability shall be applied in the sliding bearings.

## 4.2 Rail supporting structure

- Subject to section 4.1 and except where otherwise specified herein all steelwork used for Rail Supporting Structures shall comply with the requirements contained in [5].
- The Manufacturer shall propose protective treatments to the Rail Supporting Structure which shall comply with [5].

## 4.3 Rail assembly components

- Unless stated otherwise herein, all materials and components shall comply with the relevant railway standards.
- Rails shall be 60 E 1 (previous UIC60) in accordance with [7]
- Rails shall comply with [7], class X for profile requirements and class A for straightness, surface flatness and twist tolerances. Rails shall be accompanied with certificates called up in these standards.
- Rails shall be protected from corrosion. Suitable corrosion protection to any sliding surfaces shall be provided.

- All the metallic components in rail fastenings shall have a fatigue life of not less than 800 million gross tonne traffic, and shall be treated with an approved corrosion inhibitor to ensure that they remain serviceable for at least 15 years in the aggressive climatic conditions that will apply.
- Non-metallic components shall be naturally resistant to the effects of heat, ultra-violet light, oil spillage and salt spray.

### 4.4 Joints in rail assemblies

- Insulated joints will not be required within the railway expansion joints.
- Running rails shall normally be welded into long or continuous rails. There shall be no fish plated joints, and no drilling for fish bolts shall be undertaken in the running rails.
- Welds shall be located not less than 3 m longitudinally from any joint in the rail supporting structures.

## 5 Works testing

### 5.1 Prototypes and testing

1 Prototype shall be tested as specified in [4].

2 After completion of the design the manufacturer shall produce a full-scale prototype of the large type of railway expansion joint as intended for use at the terminal structure/suspension bridge location of the Messina Bridge for inspection and testing.

3 The testing and inspection shall be performed in or near the manufacturer's work shop and shall include:

3.1 Trials assembly of the complete joint, comprising rail supporting structure and rail assembly.

3.2 Trials of the longitudinal movements in the rail supporting structure and the rail assembly.

3.3 Trials of the angular rotations in the rail supporting structure and the rail assembly.

3.4 Test of the insulation resistance.

3.5 Test under static and dynamic loads. Stress in selected types of elements shall be measured for verification of the calculated fatigue life of the elements.

4 Any failure to comply with the expected results stipulated in the specification of the testing shall be recorded, remedial action shall be proposed and, after approval, by the supervision, be implemented and the tests repeated.

5 The trials referred to in sections 5.1(3.1), 5.1(3.2) and 5.1(3.3) shall be designed to show that the railway expansion joint can accommodate the movements it is required to accommodate without unpredicted dimensional distortion to any part.

6 Insulating testing as referred in section 5.1(3.4) shall demonstrate workshop compliance with the specified criteria.

7 For the tests under load, section 5.1(3.5), the manufacturer shall assemble the complete joint assembly in a suitable pit, or similar structure, with a suitable length of track, in such configuration as is agreed with the supervision as the nearest equivalent to the normal configuration prevailing on the primary bridge structure. The assembly shall be capable of simulating the full range of movements of the joint. Following satisfactory static load tests, the manufacturer shall cause a suitable load configuration for dynamic testing.

8 At the end of each test period the joint shall be inspected, and any signs of wear, loosening of fastenings, or distortion of parts recorded. Except in cases of serious wear, loosening or breakage parts shall not be replaced or fastened, the objective being to establish the rate at which such wear and tear develops, but wherever such rate is more rapid than predicted the relevant cause shall be sought and modifications proposed to the supervision. This procedure shall be continued until such time as the railway expansion joint performs as expected.

9 Upon completion of the tests under load as described above the manufacturer shall submit to the supervision full records of the tests together with proposals for such further modification as are in his opinion necessary or desirable for the satisfactory performance and durability of the railway expansion joint. Within three weeks of receiving such proposals the supervision will notify the manufacturer of such comments as he may have, and, subject to such comments, the manufacturer shall implement such modification.

10 The prototype railway expansion joint, as finally modified, shall be delivered to the site and installed as one of the operational railway expansion joints.

11 The remaining railway expansion joints shall be subject to the same testing and inspection at the manufacturer's works as specified for the prototype save that the manufacturer shall not be required to undertake the tests under load.

12 Any modifications adopted for the prototype shall be likewise incorporated in the remaining railway expansion joints.

13 On completion of testing any corresponding components of the assembly shall be marked for correct re-assembly at site.

# 6 Installation and trial running

## 6.1 Installation procedures

- For the installation of the rail assembly of the railway expansion joints the manufacturer shall abide by the conditions applicable for track work on the primary bridge structure described in [1].
- The manufacturer shall prepare a fully detailed written method statement for the installation of the railway expansion joints, which shall be submitted to the supervision for approval.

## 6.2 Trial running on bridge and maintenance

- After completing the installation of the railway expansion joints in the bridge, the manufacturer shall remain on site and his obligations in respect of the installation stage shall not be completed until the issue of the certificate of completion of the works.
- The manufacturer shall submit his recommended maintenance regime for the first year of normal railway operations following the issue of the certificate of completion which shall take account of his pre-completion inspection.
- Throughout the maintenance period the manufacturer shall retain one or more persons fully familiar with the railway expansion joint and capable, by the provision of appropriate advice

and assistance to the railway operator, of responding to any urgent situation affecting the railway expansion joints notified to him, including attending in person where necessary.

- In particular, and without limiting the generality of the above, the manufacturer shall during this period:
  - (a) Within the initial 12 weeks of the maintenance, period carry out such further adjustments or modifications, if any, as have been agreed with the supervision as a result of the pre-completion inspection.
  - (b) Attend all maintenance operations, in an advisory capacity, carried out by the railway operator in accordance with the manufacturer's precompletion inspection report.
  - (c) In conjunction with the railway operator continue to monitor the performance of the railway expansion joints by carrying out quarterly surveys and submitting reports similar to the pre-completion survey and report.
- The above provisions shall apply notwithstanding that no defect, sufficient to affect normal railway operations, is found. Whenever any such defect is found, at any time from the completion of installation to the end of the maintenance period, the manufacturer shall forthwith effect such repair or replacement as may be necessary.
- Access for such maintenance, repair or replacement of any part of the rail assembly after normal railway operations have commenced will be limited to 4 hours in every 24 and will normally be between 0100 hrs and 0500 hrs. The railway expansion joints will be accessible during normal railway operations subject to the regulations of the railway operator.

# 7 Post-installation

## 7.1 Operation and maintenance instructions

- Not less than two months prior to the handover of the railway envelope the manufacturer shall forward four draft sets of operation and maintenance instruction manuals (hereafter called "the O&M instructions") for the railway expansion joints to the supervision. Six copies of the final manuals shall be supplied within three months of the completion of the works, one

of which shall be the original. All photocopies of O&M instructions shall be properly stamped and certified as true copies of the original by the manufacturer.

- The O&M instructions shall be in Italian and English language and contain no irrelevant or ambiguous information and shall relate specifically to this contract.
- The manufacturer may use manufacturer's data and handbooks for individual items of equipment that are a sub-component of the overall system providing they meet the intent of the specification, are integrated by the manufacturer into the description of his equipment, and are indexed accordingly in his own general index.
- Where a sub-assembly item is of such a nature that local repairs cannot be made and it must be returned to the manufacturer's works as a unit for overhaul, the specific information concerning its repair and breakdown into component parts shall be provided; this shall include the circuit and wiring diagrams down to component level.
- The O&M instructions shall be collated in proper order and correspond to the contents and index tables. Nomenclature or references to *any* item of equipment, diagrams, figure numbers or units shall be consistent throughout the text. In order to comprehend the text fully, diagrams, drawings, sketches and actual photographs shall be added where necessary. All manufacturers' literature identification codes, references or stamp markings shall be omitted. Precautions and warnings regarding the safety of life and equipment shall be included where applicable.
- The cover for the O&M instructions shall be black, rigid and durable with in-laid lettering. Threaded binding posts shall not be used. The page size shall be ISO A4 and the manufacturer shall ensure that the printing will not fade with age.
- Arrangement and format of instructions shall include the following:
  - Title page and table of contents;
  - Section I - Operation, comprising:
    - General description of the system and equipment including overall design parameters and specific features with descriptive drawings to complement the particular text where practicable;

- Up to date and completed contract schedules, guarantees and performance characteristics for all equipment;
- Installation and commissioning instructions;
- Schedule of lubricants, chemicals and other consumables;
- Comprehensive records of all mechanical and electrical test results;
- Reports and certificates.

- Section II - Maintenance, comprising:
  - Dis-assembly instructions;
  - Maintenance instructions;
  - Use and interpretation of built in diagnostic aids;
  - Settings;
  - Clearance and adjustment data.
- Section III - Parts catalogue comprising:
  - Replacement parts, drawings and tabulated lists of assemblies and subassemblies of the railway expansion joints; the tabulated lists shall include part names, numbers, equipment serial numbers and ordering codes etc.
  - Complete instructions for ordering replacement parts in a manner that would prevent errors or misunderstanding when ordering, recommended forms for requisition of replacement parts from the factory shall also be included and special storage or handling procedures for any parts shall be noted.
  - Associated publications which shall contain where applicable manufacturers' existing publications or sub-assembly or associated equipment components for major units of plant and shall be collated at the back of each volume.
  - As a result of experience gained during commissioning and initial operation, it is anticipated that revisions to the O&M instructions will be found necessary. No later than two months after the issue of the certificate of completion for the works

the manufacturer shall submit such revisions to the supervision for approval and provide the same number of copies as stated above.

## 7.2 As-built drawings and records

The manufacturer shall be required to prepare all necessary drawings and diagrams of the as-built railway expansion joints as may be required for record and for the purposes of care, maintenance and repair. These shall be submitted at the time of handover of the railway movement joint.

## 7.3 Staff training

- Immediately prior to installation of the first of the railway expansion joints the manufacturer shall provide an introductory training seminar in the vicinity of the site for not more than 12 trainees.
- The seminar shall be conducted in Italian or English, as desired by the supervision, at a suitable classroom location provided by the manufacturer and shall cover:
  - The principles adopted for the design of the joints.
  - The nature, source and scale of the movements it accommodates.
  - The materials used and the reason for their selection.
  - The manufacturing trial assembly and works testing process including tests and equipment use.
  - The planned installation procedure.
  - The proposed post-installation inspection monitoring and maintenance procedures.
- The seminar shall include visual aids to illustrate all aspects including a video film of (d) above, and a suitably illustrated set of course notes which shall include an English translation.
- During installation the manufacturer shall organize not less than eight further half day guided visits, each visit attended by half the number of trainees. The visits shall be four to the Calabrian side joints and four to the Sicily side joints and at each location two of the visits

shall coincide with critical aspects of the installation of the rail supporting structure, and two with the installation of the rail assembly.

- After installation is complete, in the period prior to the issue of the certificate of completion, the manufacturer shall arrange not less than three further guided visits for all trainees to familiarize them with the inspection and monitoring procedures adopted and the practical operation of the joints. At the final visit an updated version of the original course notes will be provided taking account of all modifications to equipment, materials or procedures used.
- The objective to be achieved is that from the commencement of normal railway operations a sufficient number of railway operator's maintenance staff will be fully trained and capable of maintaining, repairing and replacing the railway expansion joints or any component parts.

### 7.4 Spares

- 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.
- The manufacturer shall prepare a list of recommended replacement parts during the maintenance period in sufficient time for them to be supplied to-the railway operator before the expiry of the maintenance period.

### 7.5 Special tools

The manufacturer shall supply any special tools which may be necessary for maintenance or replacement of the railway expansion joints.

## 8 Submissions

Schedule for the manufacturers submissions shall be agreed with the supervision.

### 8.1 Design submissions

- The manufacturer shall submit to the works supervision 8 copies of a report setting out the detailed principles of his proposals for the railway expansion joints together with calculations

and drawings and preliminary details of testing proposals including the proposed prototype testing rig.

- The manufacturer shall coordinate his work with the main manufacturer with regard to the interfacing railway works, including, but not limited to, rail adjacent to the railway expansion joints, the transitions between the railway expansion joints and plain track, holding down fixings and steelwork connections.
- The manufacturer shall submit 8 copies of the final working drawings and a full specification of materials and workmanship, together with final supporting calculations.
- The manufacturer shall submit a declaration of compatibility, stating that the railway expansion joints are suitable for functioning under the actual conditions regarding support and general arrangement of the adjacent structure.