GENERAL WORK SPECIFICATION CONCRETE BRIDGE – PRESTRESSED REINFORCEMENT – GWS

TENDER

NOVEMBER 2018

DISCLAIMER

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1 GENERAL

1.1 References

The specified references apply in the most recent edition with auxiliary amendment sheets and appendices, as well as any national annexes.

The following standards and specifications shall apply to the work in the order stated, including any supplements and deviations stated in the Work Specification as well as in the additional Project Documents:

- DSF/FprEN 10138-1 Prestressing steels Part 1: General requirements
- DSF/FprEN 10138-2 Prestressing steels Part 2: Wire
- DSF/FprEN 10138-3 Prestressing steels Part 3: Strand
- DSF/FprEN 10138-4 Prestressing steels Part 4: Bar
- DS/EN 1992-2 Eurocode 2: Concrete structures Part 2: Concrete bridges Design and detailing rules
- DS/EN 1992-1-1 Eurocode 2: Concrete structures Part 1-1: General rules and rules for building structures
- DS 2427 Concrete execution Rules for application of EN 13670 in Denmark
- DS 2426 Concrete Materials. Rules for application of EN 206-1 in Denmark
- DS/INF 165 Reinforcing steel for concrete structures Identification and classification pursuant to EN 10080 and EN 10138
- DS/EN 10204 Metallic products Types of inspection documents.
- DS/EN 445 Grout for prestressing tendons Test methods.
- DS/EN 446 Grout for prestressing tendons Grouting procedures.
- DS/EN 447 Grout for prestressing tendons Basic requirements.
- DS/EN 197-1 Concrete Part 1: Composition, specifications and conformity criteria for common cements.
- DS/EN 523 Steel strip sheaths for prestressing tendons. Terminology, requirements, quality control.
- DS 1050 Construction tolerances Use of dimensional tolerances.

The guidelines, notes etc. stated in the references shall be regarded as requirements that shall only be deviated from if thus stated in the Project Documents.

Henceforth, DSF/FprEN 10138-1 to 4 are designated as DS/EN 10138 in keeping with the nomenclature in DS/INF 165.

For prestressed reinforcement, requirements can be found in DS/EN 1992-1-1 (Section 3.3), EN 1992-1-1 DK NA and DS/EN 10138. In DS/INF 165, Reinforcing steel for concrete structures – Identification and classification in accordance with DS/EN 10080 and DS/EN 10138, there is an overview and summary of the requirements that apply to prestressed reinforcement.

For the making of prestressed reinforcement for concrete elements under harmonised standards, the parts of the present requirement document apply, which is stated in Concrete Bridge – Concrete Elements – GWS, Section 1.1.

1.2 Documentation

Documentation for prestressed reinforcement, grout and the prestressed reinforcement system, i.e. anchorages, couplers, ducts and other related parts to be used, shall be forwarded to the Client

for review and comments no later than 20 working days prior to ordering. The documentation for prestressed reinforcement shall include type documentation.

Documentation for the prestressed reinforcement used shall be forwarded to the Client for review and comments no later than 10 working days prior to the commencement of the works.

1.2.1 Prestressed reinforcement

The prestressed reinforcement shall both be produced pursuant to the provisions in EN 1992-1-1 DK NA and certified pursuant to the provisions in EN 1992-1-1 DK NA, Section 3.3.1 General. Documentation to this effect shall be available.

Prestressed reinforcement shall be documented as set out in DS/INF 165 as well as the additional requirements set out in Section 2.1. Furthermore, for wires and strands, the following shall be stated:

- Name of the manufacturing plant
- The stress-strain curve determined as stated in DS/EN 10138.

and for bars:

- Name of the manufacturing plant
- Manufacturing process
- The stress-strain curve determined in accordance with DS/EN 10138.

The latter shall be stated if requirement is set to that effect in the Project Documents.

Prestressed reinforcement shall be delivered with Inspection Certificate 3.1.

For prestressed reinforcement documentation for additional tests shall be appended, as stated in Section 1.4.

1.2.2 Prestressed reinforcement system, including anchorages, couplers, ducts etc.

If no European Technical Approval (ETA) is available for the prestressed reinforcement system, the entire range of requirements included in the European Technical Approval shall be met otherwise.

For anchorages and couplers, systems shall only be used which consist of original parts and moreover which, by testing and long-term use and practice, have created documentation of their safe function and failure characteristics.

Ducts and associated joints shall be documented in pursuance of DS/EN 523 and the additional requirements stated in Section 2.2.

1.2.3 Grout

Grout shall be documented in pursuance of DS/EN 447 and the additional requirements stated in Section in 2.3.

Cement for grout work shall be CE marked.

1.2.4 Tensioning

Tensioning of the prestressed reinforcement shall be documented. The documentation shall contain data of significance in relation to the assessment of the completed work, including, e.g. particulars on and records concerning tensioning lists, times, force measurements and measured elongations.

1.2.5 Execution of grouting

The grouting work shall be documented. The documentation shall contain particulars of significance for the assessment of the completed work, including particulars on and records of:

- Grouting programme covering location of ports/vents, inflow, outflow and deviations from the closure sequence.
- Materials used.
- Equipment used.
- Times
- Climatic and temperature conditions.
- Quantities used.
- Particulars on results of tests made with regard to fluidity, expansion, water separation and change of volume as well as strength.
- Comments on stops, leakages, etc.
- Observations from the port/vent inspection and any consequences thereof.

1.2.6 Execution of the prestressed reinforcement work

The work of ducts, prestressed reinforcements, couplers, anchorages, tensioning and grouting shall be carried out under the management of a person with sufficient experience and knowledge of prestressed reinforcement design, tensioning, grout production and execution of grouting. The person's qualifications shall be documented and submitted to the Client for review and comments.

Staff carrying out the work shall have documented knowledge and experience with prestressed reinforcement work.

1.3 Investigations

The work may include demolition work for the exposure of prestressed reinforcement arrangements.

When the reinforcement has been exposed, the Client shall make an inspection and prepare a supplementary description of the works to be carried out.

1.4 Testing and measurements

1.4.1 Additional testing of prestressed reinforcement properties

For prestressed reinforcement in concrete structures assigned to a more rigorous control class, the documentation for prestressed reinforcement properties shall be supplemented by testing.

One specimen shall be taken and tested for every 25 t of delivered prestressed reinforcement, but at least 3 specimens per delivery and load.

Specimens shall be taken in the presence of the Client or a third party approved by the Client.

The specimens shall be tested in a laboratory accredited to conduct the tests.

The test shall include determination of:

- 0.1% proof stress
- tensile strength (corresponding to peak value)
- ductility expressed in terms of ε_{uk} and $(f_{pk} / f_{p0.1 k})$
- stress-strain curve
- modulus of elasticity.

Test certificates shall be submitted to the Client for comments. The Contractor shall not commence casting of the structures involved before the Client's comments are available.

1.4.2 Concrete compressive strength in connection with tensioning

On the casting of concrete in the structure, at least 18 cylinders shall be cast at the same time and kept under the same curing conditions as the concrete in the structure.

Compression testing of the 18 cylinders shall be carried out, subject to agreement with the Client, prior to the tensioning operation.

1.4.3 Measurement of concrete cover

After the concrete casting and curing, the cover of 5% of the concrete surfaces shall be measured by means of a covermeter or similar method.

Measuring areas are selected as spot checks focusing on the areas where the risk of failure is the highest. Measuring programme, including selection of measuring areas, and a method for recording data shall be submitted to the Client for review and comments.

For concrete elements the Contractor shall, prior to built-in, measure the cover pursuant to the guidelines above. Elements, of which errors are found in the cover, shall not be mounted without the Client's a written consent.

If measurements show non-compliance with requirements, the Client shall be contacted immediately for clarification of further procedures.

1.4.4 Testing of grout properties

For each verification section, as a minimum, the following specimens shall be taken:

- 1 fluidity measurement when the grouting starts as well as following each pause in the grouting work. The specimen shall be taken directly from mixing or storage containers. Further, fluidity measurements shall be made at least every three hours. At least 5 grout fluidity measurements shall be carried out, taken at the end of the duct
- 1 measurement of expansion, water separation and water reabsorption in the grout taken from the mixing or storage container
- 1 measurement of expansion, water separation and water reabsorption in the grout taken from the duct
- Specimens for strength testing as stated in DS/EN 447.

Test results shall be submitted to the Client.

2 MATERIALS

2.1 Prestressed reinforcement

Terms, symbols, etc. used are in accordance with DS/INF 165.

Specifications are in pursuance of DS/INF 165.

 $(f_{pk}/f_{p0.1k})$, which is the relationship between the tensile strength and the 0.1% proof stress, shall comply with the requirement $(f_{pk}/f_{p0.1k}) \ge 1.1$.

The elongation at rupture shall comply with the requirement $\varepsilon_{uk} \ge 3.5\%$.

Prestressed reinforcement shall be without visible manufacturing defects such as cracks, flaws, splitting, etc.

Wires and strands shall be post-treated to remove residual stress.

Wires used in prestressed concrete shall be indented wire.

Threads for bars shall be rolled.

Prestressed reinforcement shall be supplied with a charge number, and test results shall be relatable to these.

2.2 Prestressed reinforcement system, including anchorages, couplers and ducts

Couplers and coupler casings for both fixed and moveable couplers shall be designed so as to allow full injection with grout. The necessary number of drains and vents shall be built-in, corresponding to the design assumption of tensioning and grouting in one or more stages.

For fixed couplers it shall be possible for grouting to be performed optionally before or after the coupled reinforcement has been prestressed.

Ducts shall be made of steel and shall not be surface-treated, i.e. galvanised or the like.

Ducts shall be Class 2 in pursuance of DS/EN 523, and shall comply with the requirements which appear from the tensioning system being used.

2.3 Grout

Grout shall meet the requirements in DS/EN 447 as well as the additional requirements below.

2.3.1 Constituent materials

Manufacturers of cement shall certify compliance with DS 2426.

Type CEM I cement in pursuance of DS/EN 197-1 shall be used.

The chloride content from additives shall not exceed 0.10%.

Aluminium powder (as intrusion aid) shall be permitted to be used to a limited extent.

2.3.2 Composition

The composition of the mortar and properties shall be documented as stated in DS/EN 446.

After 24 hours, the mortar shall have a volumetric expansion of between 0% and 6%, measured at 1 atmospheric pressure (0.1 MPa).

The mortar properties shall be determined prior to execution.

2.3.3 Compressive strength

Compressive strength determined under DS/EN 447 shall be considered equal to 0.9 f_{ck} , where f_{ck} is the compressive cylinder strength pursuant to DS 2426.

3 EXECUTION

3.1 General

The Contractor shall prepare a plan of procedures for receipt and storage of materials and products.

Subject to DS/EN 13670, the Contractor shall, before the work commences, prepare a programme for the prestressed reinforcement and related parts. The programme shall be submitted to the Client for review and comments prior to the work(s) commences.

The prestressed reinforcement and related elements displayed on the drawings and in the building models are drawing symbols showing the principle of the reinforcement design.

The purpose of the drawing symbols is to give a clear indication of the reinforcement layout, e.g. the reinforcement may be drawn slightly staggered compared to its actual location, but this shall not entitle the Contractor to deviate from requirements for concrete cover, bending diameters etc.

The Contractor shall, to the extent necessary, prepare working drawings to establish the correct reinforcement layout.

All deviations from the reinforcement design shown are subject to the Client's consent.

If, during the execution of the work related to prestressed reinforcement and related parts, there are deviations in relation to the set requirements, guidelines, procedures, etc. and damage occurs, the Client shall immediately be notified.

3.2 Tolerances

The tolerances stated in DS/EN 13670 shall apply. Where Tolerance Class 2 is found, this class applies; otherwise Tolerance Class 1 shall apply.

For location of ducts the following tolerances apply:

- Individually: ± 20mm shall apply, instead of ± 30mm as stated in DS/EN 13670
- Groups: ± 10mm.

3.3 Prestressed reinforcement

The Contractor shall prepare a plan, so that the prestressed reinforcement shown on the project drawings may clearly be identified by the applied charge numbers.

As part of the programme described in section 3.1, the Contractor shall prepare a plan of the procedure for installing prestressed reinforcement.

3.4 Pre-bending

Pre-bending of bars shall be done in the cold state by means of a bending machine, whose suitability is documented, so that after bending the bars continue to meet the requirements for reinforcement properties.

All bars with a radius of curvature less than 20m shall be pre-bent. Other bars shall be pre-bent, in case fixing in place cannot be done with sufficient accuracy.

3.5 Thermal stress

Prestressed reinforcement and related parts shall not be exposed to heating of any kind which may impair the prestressed reinforcement properties after cold drawing has taken place.

Heating includes, e.g. welding, exposure to welding spatter, flame-cutting and burning both on and in the immediate vicinity of the prestressed reinforcement and related parts.

3.6 Cover

The cover, as regards durability and tolerance on the cover, shall comply with the requirements stated in EN 1992-2 DK NA.

The prescribed (nominal) cover depth shall be determined by $c = (c_{min} + \Delta c_{dev}) \pm \Delta c_{dev}$.

3.7 Ducts

As part of the programme described in section 3.1, the Contractor shall make a plan of procedures for venting and draining of ducts.

As a minimum, the ducts shall be fixed at the support points stated in the Project Documents.

The distance between vents and drains shall not exceed 35m.

Ducts and their joints shall be tight to avoid water ingress.

Dented or otherwise damaged ducts shall be replaced.

If prestressed reinforcement is installed in ducts before casting of the surrounding concrete, shortening etc. of ducts shall only be made by means of plate shears, i.e. a hacksaw, file, etc. must not be used.

Until grouting has been carried out, the ducts shall constantly be kept free of water, for example through drains and blowing through by dry compressed air to the extent necessary. All openings to the outside shall be kept covered.

If the interval between the installation of the prestressed reinforcement and grouting exceeds 12 weeks, the Contractor shall initiate necessary measures to safeguard the prestressed reinforcement against corrosion. Proposals for measures shall be submitted to the Client for approval.

3.8 Completion prior to casting

All work with ducts, anchorages, couplers, prestressed reinforcement etc. for a casting section shall be completed prior to casting of the relevant casting section commences. Deviations from this shall be submitted to the Client for approval.

Immediately before the casting of concrete, all ducts, drains and vent pipes, the connection of the anchorages to the form etc. shall be inspected and sealed, so that grout cannot enter into any part of the ducts and anchorages and thus impede tensioning and grouting.

The Client shall have the opportunity to inspect ducts, anchorages, couplers, prestressed reinforcement, etc. prior to casting. The Client shall be notified no later than 2 working days before casting takes place.

3.9 Tensioning

As part of the programme, described in Section 3.1, the Contractor shall prepare a tensioning plan based on the tensioning lists. The tensioning plan shall contain all relevant conditions for the tensioning and its progress.

Final tensioning must only take place, when the concrete has obtained the specified strength for tensioning. The ensuring that the concrete has achieved the specified strength shall be based on the concrete maturity, supplemented by compression testing of at least 3 cast cylinders, cf. Section 1.4. The other cylinders shall be used at later key dates, if the first results do not render it probable that the concrete has obtained the prescribed strength.

Before the final tensioning, preliminary tensioning shall be carried out as stated below.

3.9.1 Preliminary tensioning

Under normal weather conditions, preliminary tensioning shall be carried out approximately 3 days of maturing after completion of casting, and shall consist of temporary and limited tensioning to counter the effects of concrete shrinkage (10-30% of the final total prestressing force applied evenly over the cross-section). The starting point in time shall be based on the concrete maturity and is subject to agreement with the Client.

3.9.2 Final tensioning

If the tensioning causes elongations exceeding the tolerances, stated in the tensioning lists, the Client shall be contacted for agreement on further progress of the work.

3.10 Tensioning equipment

All tensioning equipment shall be maintained and documented with a calibration certificate.

Instructions related to the tensioning system shall be complied with in the calibration of jacks and related measuring systems.

The calibration certificate, which must not be older than 6 months, shall contain a calibration curve providing correlation between the measuring system values (manometers, load transducers, etc.) and the load generated by the jacks.

The accuracy of the measured values shall be stated for the entire calibration curve. The inaccuracy of the measured values must not exceed 2% of the related load effect.

3.11 Grouting

Grouting shall be carried out in compliance with the requirements of DS/EN 446.

As part of the programme described in Section 3.1, the Contractor shall prepare a grouting programme, which i.a. shall account for:

- Execution of grouting.
- Division into control sections.
- Grouting quantities for each duct.
- Measures to ensure complete filling with grout, including any post-grouting at i.a. coupler casings and anchorage trumpets.
- Possibilities for flushing and cleaning ducts in the event of accidents during the execution of the grouting.
- The equipment used.
- Back-up equipment that will be available during the execution of the grouting.

Grouting must not be started before the documentation for the tensioning has been reviewed and commented on by the Client.

Before grout is pumped into ducts, the groutability of the ducts shall be checked by blowing through using compressed air.

Grouting shall only take place at the temperatures stated in DS/EN 446. In the event of deviations from these, the Contractor shall submit proposals that ensure the quality of the grouting. Procedures are subject to the Client's consent.

During grouting, a compressor and pressurised water (at least 0.1 N/mm²) in ample quantities shall be kept available for flushing and cleaning ducts, in the event of grouting breakdown.

Back-up pumps and mixing equipment shall be present to the extent required.

Measures shall be taken to ensure complete filling of coupler casings and anchorage trumpets, i.a. by post-grouting them at a suitable time before setting of the grout.

It shall be possible to inspect and regrout couplers, e.g. through cast-in tubes leading to the upper parts of the couplers. Immediately after use, these tubes shall be filled with grout.

For grouting of vertical cables, special measures shall be taken so that the cable duct stays completely filled after the curing of the grout. The programme and adequacy of the measures shall be documented by full-scale tests, prior to the execution of the actual grouting.

3.12 Cast in of anchorage devices

The surface of the existing concrete in the area surrounding the anchorage to be cast in shall meet the requirements in DS/EN 1992-1-1 for rough construction joints, as well as the requirements otherwise stated for the execution of construction joints in GWS - CONCRETE.

Casting shall only take place when the Client has reviewed and commented on the documentation for the grouting work.

4 CHECKING

4.1 General

Checking shall be carried out in accordance with DS 2427 and DS/EN 13670.

The Contractor shall prepare a plan of procedures for checking of materials, receipt of materials and execution.

Documentation of checking shall be available in the form of check records stating the extent of the checking, check results, time, inspector, etc.

The plan for procedures, layout of check records, etc. shall be presented to the Client for review and comments before commencement of the work.

Measured thicknesses of concrete cover, cf. 1.4, shall be checked against the stated requirements.

Copies of completed check records shall be submitted to the Client on an ongoing basis.

4.2 Casting

Ducts, couplers, drains and vent pipes, and anchorage connections to the forms shall be checked for complete tightness against ingress of any kind before casting begins.

4.3 Tensioning equipment

Manometers for tensioning equipment shall be checked on site by means of control manometers before and after tensioning. In case any suspicion of irregularities occurs, checking during the execution of the work shall also be carried out.

When the equipment has been, or there is suspicion that it has been, exposed to inappropriate treatment (impact, vibration, overload, etc.), the checking will have to be repeated.

4.4 Grouting

During grouting, it shall be checked on an ongoing basis that the quantities used correspond to the expected consumption.

Check records with documentation for all work, related to grouting, shall be kept.

When the grouting nozzles are removed, after the grouting mortar has set, the nozzles shall be checked for filling. If defective filling of nozzles is found, an investigation into the reason and the actual conditions shall be carried out. The description thereof and suggestions for rectification are subject to the Client's consent.



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