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Authorised and notified according to Article 10 of the Council Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products (89/106/EEC)

Deutsches Institut für Bautechnik

DIBt

Mitglied der EOTA
Member of EOTA

European Technical Approval ETA-13/0330

English translation prepared by DIBt - Original version in German language

Handelsbezeichnung *Trade name*	Hybridturm System Max Bögl *Hybrid-tower system Max Bögl*
Zulassungsinhaber *Holder of approval*	Max Bögl Wind AG Max-Bögl-Straße 1 92369 Sengenthal DEUTSCHLAND
Zulassungsgegenstand und Verwendungszweck *Generic type and use of construction product*	Stahlbetonfertigteil zur Verbindung des Stahl- und Betonteils von Hybridtürmen unter Verwendung von Vorspannung ohne Verbund. *Prefabricated reinforced concrete connection-element for joining the steel- and concrete-part of hybrid-towers by use of prestressing without bond*
Geltungsdauer: *Validity:*	vom *from* 12 June 2013 bis *to* 12 June 2018
Herstellwerke *Manufacturing plants*	Max Bögl Fertigteilwerke GmbH & Co. KG Max-Bögl-Straße 1 92369 Sengenthal DEUTSCHLAND Max Bögl Albert-Betz-Straße 24783 Osterrönfeld DEUTSCHLAND

Diese Zulassung umfasst *This Approval contains*	22 Seiten einschließlich 6 Anhänge *22 pages including 6 annexes*

I LEGAL BASES AND GENERAL CONDITIONS

1 This European technical approval is issued by Deutsches Institut für Bautechnik in accordance with:

- Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of Member States relating to construction products[1], modified by Council Directive 93/68/EEC[2] and Regulation (EC) N° 1882/2003 of the European Parliament and of the Council[3];
- *Gesetz über das In-Verkehr-Bringen von und den freien Warenverkehr mit Bauprodukten zur Umsetzung der Richtlinie 89/106/EWG des Rates vom 21. Dezember 1988 zur Angleichung der Rechts- und Verwaltungsvorschriften der Mitgliedstaaten über Bauprodukte und anderer Rechtsakte der Europäischen Gemeinschaften (Bauproduktengesetz - BauPG) vom 28. April 1998[4], as amended by Article 2 of the law of 8 November 2011[5];*
- Common Procedural Rules for Requesting, Preparing and the Granting of European technical approvals set out in the Annex to Commission Decision 94/23/EC[6].

2 Deutsches Institut für Bautechnik is authorized to check whether the provisions of this European technical approval are met. Checking may take place in the manufacturing plant. Nevertheless, the responsibility for the conformity of the products to the European technical approval and for their fitness for the intended use remains with the holder of the European technical approval.

3 This European technical approval is not to be transferred to manufacturers or agents of manufacturers other than those indicated on page 1, or manufacturing plants other than those indicated on page 1 of this European technical approval.

4 This European technical approval may be withdrawn by Deutsches Institut für Bautechnik, in particular pursuant to information by the Commission according to Article 5(1) of Council Directive 89/106/EEC.

5 Reproduction of this European technical approval including transmission by electronic means shall be in full. However, partial reproduction can be made with the written consent of Deutsches Institut für Bautechnik. In this case partial reproduction has to be designated as such. Texts and drawings of advertising brochures shall not contradict or misuse the European technical approval.

6 The European technical approval is issued by the approval body in its official language. This version corresponds fully to the version circulated within EOTA. Translations into other languages have to be designated as such.

1 Official Journal of the European Communities L 40, 11 February 1989, p. 12
2 Official Journal of the European Communities L 220, 30 August 1993, p. 1
3 Official Journal of the European Union L 284, 31 October 2003, p. 25
4 *Bundesgesetzblatt Teil I 1998*, p. 812
5 *Bundesgesetzblatt Teil I 2011*, p. 2178
6 Official Journal of the European Communities L 17, 20 January 1994, p. 34

II SPECIFIC CONDITIONS OF THE EUROPEAN TECHNICAL APPROVAL

1 Definition of product/ products and intended use

1.1 Definition of the construction product

This European technical approval refers to the prefabricated reinforced concrete connection-elements made of self compacting concrete. The element is used for joining the steel- and concrete-part of hybrid towers of wind energy plants by use of prestressing without bond. The self compacting concrete has a compressive strength in the range of C70/85 to C100/115. The prefabricated elements are rings of cylindrical or conical shape. The top and the outside of the connection-element will be covered by a steel-shell. For the prestressing system which is used for joining the steel- and concrete-part a separate technical approval (ETA) shall be available.

1.2 Intended use

The connection-element is intended to be used for structural purposes in hybrid-towers for joining the structural steel- and concrete-part of the tower by use of prestressing without bond, (see Annex 1).

All internal forces resulting from actions on the steel- and/or concrete-part of the hybrid tower shall be transferred by the connection-element to the corresponding part of the structure as planned by providing sufficient stiffness to fulfill the requirements in terms of deformations (SLS).

1.3 Intended working life

The provisions made in this European technical approval are based on an assumed working life of the connection-element for the intended use of 25 years; provided that the conditions laid down in the European technical approval for the packaging/transport/storage/installation/use/ maintenance/repair are met.

The indications given as to the working life of the construction product cannot be interpreted as a guarantee given by the producer, but are regarded only as a means for choosing the appropriate products in relation to the expected economically reasonable working life of the works.

2 Characteristics of the construction product and methods of verification

2.1 Characteristics of the product

2.1.1 Geometry

The wall thickness of the precast elements is 25 cm to 110 cm. The diameter is in the range of 1.5 m to 7 m, and the height of the connection-element is between 1 m to 3.5 m.

All dimensions of the element are shown in Annex 2.

2.1.2 Material Properties

2.1.2.1 Concrete

The concrete is self compacting concrete with a compressive strength in the range of C70/85 to C100/115 which shall be in accordance with EN 206-1 and EN 206-9. The common rules of EN 13369 shall be taken into account.

For concrete with compressive strength class C70/85 to C100/115, in addition to the requirements of EN 206-1 and EN 206-9 the flexural tensile strength (Prism: 150 x 150 x 700 mm) and the modulus of elasticity shall meet the requirements according to Annex 3.

The composition of the concrete is laid down in the technical documentation deposited with Deutschens Institut für Bautechnik.

The concrete compressive strength shall be determined according to EN 12390-3.

The tensile strength shall be calculated from the flexural tensile strength according to EN 1992-1-1.

The flexural tensile strength shall be determined according to EN 12390-5. The modulus of elasticity shall be determined according to prEN 12390-13:2012.

2.1.2.2 Reinforcement steel

Reinforcement steel bars or wire fabrics shall be in accordance with the properties laid down in EN 1992-1-1, 3.2 and EN 10080:2005.

Bars class B or C and wire fabrics classes A, B or C according to EN 1992-1-1, Annex C, Table C.1 with a nominal maximum yield strength of $f_{y,k}$ = 500 N/mm² and a nominal minimum yield strength of $f_{y,k}$ = 400 N/mm² shall be used.

Welding of reinforcement steel shall be in accordance with EN 1992-1-1, 3.2.5 and EN ISO 17660-1 and, if applicable EN ISO 17660-2.

The regulations of EN 13369 shall be taken into account.

The properties of reinforcing steel shall be determined according to national provisions valid in the place of use. It shall be documented that the requirements stated in the national standard meet the requirements given in EN 1992-1-1, Annex C.

2.1.2.3 Structural steel

The structural steel components shall meet the requirements of EN 10025-1 to EN 10025-6 and the design shall comply with EN 1993-1-1.

2.1.2.4 Structural bolting assemblies

Structural bolting assemblies shall meet the requirements of EN 14399-1, EN 14399-4 and the DASt-Richtlinie 021 (DASt-Guideline 021) or EN 15048-1.

2.1.3 Reaction to fire

The connection-element is considered to satisfy the requirements for performance class A1 of the characteristic reaction to fire, in accordance with the provisions of EC decision 96/603/EC[7] (as amended[8]) without the need for testing on the basis of its listing in that decision.

2.1.4 Resistance to fire

The part of the works or assembled system in which the prefabricated reinforced concrete connection-element is intended to be incorporated, installed or applied shall be designed using the methods and rules of EN 1992-1-2 and EN 1993-1-2, and classified to the corresponding fire resistance class "R" (load-bearing capacity), expressed in minutes according to the decision 2000/367/EC[9].

National Annexes of the standards with nationally determined parameters should be considered.

2.1.5 Content and/or Release of dangerous substances

The connection-element does not contain substances which shall be labelled with "T+" or "T" in accordance with Directive 67/548/EEC and Regulation (EC) No 1272/2008.

Carcinogenic (T, R 45; T, R 49) and mutagenic (T, R 46) substances of categories 1 and 2 in accordance with Directive 67/548/EEC and Regulation (EC) No 1272/2008 shall not be used.

7 OJ L267/23 of 19/10/1996
8 Amendment 2000/605/EC OJ L258/36 of 12/10/2000, amendment 2003/424/EC OJ L144/9 of 12.06.2003
9 Official Journal of the European Communities L133/26 of 06/06/2000

The manufacturer has in this respect submitted a written declaration to the approval body stating that the connection-element (concrete, steel, reinforcement steel and prestressing steel) does not contains substances which have to be classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and/or listed in the "Indicative list on dangerous substances" of the EGDS - taking into account the installation conditions of the construction product and the release scenarios resulting from there.

Therefore, no additional regulations due to the European technical approval and / or any additional assessment are necessary.

2.2 Methods of verification

2.2.1 General

Mechanical resistance shall be determined following the verification formats and rules of EN 1992-1-1 and EN 1993-1-1. The deviations from the Eurocodes and EN 13225 are set out in the following chapters/clauses.

Design of Structural bolting assemblies shall meet the requirements of EN 14399-1, EN 14399-4 and the DASt-Richtlinie 021 or EN 15048-1.

2.2.2 Resistance to Material fatigue

Material fatigue design shall be carried out considering the statements according to Annex 4.

2.2.3 Resistance to eccentric longitudinal force

The computation of the bursting reinforcement due to splitting tensile stresses shall be carried out considering the procedure according to Annex 5.

2.2.4 Durability

Assessment to resistance to corrosion shall be carried out according to clause 2.2.4 and shall meet the requirements of the standards, valid at the place of use.

2.2.4.1 Concrete/Reinforcement steel

Corrosion protection of the reinforcement is ensured by sufficient concrete cover. The prescriptive specifications of EN 1992-1-1 and EN 206-1 and EN 206-9 regarding exposure classes as well as the standards and regulations applicable at the place of use shall be fully met. The regulations of EN 13369, 4.3.7 are taken into account.

2.2.4.2 Structural steel

The corrosion protection of steel components shall be ensured by a coating according to EN ISO 12944-1 to EN ISO 12944-8.

2.2.4.3 Structural bolting assemblies

Structural bolting assemblies shall be galvanized according to the current state of art.

2.2.5 Safety in case of fire

2.2.5.1 Reaction to fire

The connection-element is considered to satisfy the requirements for performance class A1 of the characteristic reaction to fire, in accordance with the provisions of EC decision 96/603/EC[7] (as amended[8]) without the need for testing on the basis of its listing in that decision.

2.2.5.2 Resistance to fire

The part of the works or assembled system in which the prefabricated reinforced concrete connection-element is intended to be incorporated, installed or applied shall be designed using the methods and rules of EN 1992-1-2 and EN 1993-1-2, and classified to the corresponding fire resistance class "R" (load-bearing capacity), expressed in minutes according to the decision 2000/367/EC[9].

National Annexes of the standards with nationally determined parameters should be considered.

3 Evaluation and attestation of conformity and CE marking

3.1 System of attestation of conformity

According to the communication of the European Commission[10] the system 2+ of the attestation of conformity applies.

This system of attestation of conformity is defined as follows:

System 2+: Declaration of conformity of the product by the manufacturer on the basis of:

(a) Tasks for the manufacturer:

(1) initial type-testing of the product;
(2) factory production control;
(3) testing of samples taken at the factory in accordance with a prescribed test plan.

(b) Tasks for the notified body:

(4) certification of factory production control on the basis of:
- initial inspection of factory and of factory production control;
- continuous surveillance, assessment and approval of factory production control.

Note: Approved bodies are also referred to as "notified bodies".

3.2 Tasks and responsibilities of the manufacturer and notified bodies

3.2.1 Tasks of the manufacturer

3.2.1.1 Factory production control

The manufacturer shall exercise permanent internal control of production. All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic manner in the form of written policies and procedures, including records of results performed. This production control system shall ensure that the product is in conformity with this European technical approval.

The manufacturer may only use initial materials stated in the technical documentation of this European technical approval.

The factory production control, including initial type–testing of product, shall be in accordance with the control plan which is part of the technical documentation of this European technical approval. The control plan is laid down in the context of the factory production control system operated by the manufacturer and deposited with Deutsches Institut für Bautechnik (DIBt).[11]

The results of the factory production control shall be recorded and evaluated in accordance with the provisions of the control plan.

The records shall include at least the following information:

- Description of the product and the initial materials and the components,
- type of control or testing,
- date of manufacture and testing of the construction product and initial material or components,
- results of the inspections and testing and, if appropriate, comparison with requirements and
- Signature of person responsible for factory production control.

[10] Letter of the European Commission of 02/03/2012 to EOTA

[11] The control plan is a confidential part of the European technical approval and only handed over to the approved body involved in the procedure of attestation of conformity. See section 3.2.2.

The records must be kept for at least five years and submitted to the involved external controlling body and approval body.

In cases of unsatisfactory tests, the manufacturer shall immediately take the necessary measures to remedy the defect. Products that do not meet the requirements must be handled so that confusion with those satisfying the requirements are excluded.

3.2.1.2 Other tasks for the manufacturer

The manufacturer shall, on the basis of a contract, involve a body which is approved for the tasks referred to in section 3.1 in order to undertake the actions laid down in section 3.2.2. For this purpose, the control plan referred to in sections 3.2.1.1 and 3.2.2 shall be handed over by the manufacturer to the approved body involved.

3.2.2 Tasks for the notified (approved) body

The approved body shall perform the certification of factory production control on the basis of:

- initial inspection of factory and of factory production control,
- continuous surveillance, assessment and approval of factory production control

in accordance with the provisions laid down in the control plan.

The approved body shall retain the essential points of its actions referred to above and state the results obtained and conclusions drawn in a written report.

The approved certification body involved by the manufacturer shall issue an EC certificate of conformity of the product stating the conformity with the provisions of this European technical approval.

In cases where the provisions of the European technical approval and its control plan are no longer fulfilled the certification body shall withdraw the certificate of conformity and inform Deutsches Institut für Bautechnik without delay.

3.3 CE marking

The CE marking shall be affixed on a label which is fixed at each precast element. The letters "CE" of the connection-element shall be followed by the identification number of the approved certification body, where relevant, and be shall be accompanied by the following information:

- the name and address of the producer (legal entity responsible for the manufacture),
- the last two digits of the year in which the CE marking was affixed,
- the number of the EC certificate for the factory production control,
- the number of the European technical approval,
- geometrical dimensions and weight,
- concrete compressive strength,
- reaction to fire,
- resistance to fire.

4 Assumptions under which the fitness of the product for the intended use was favourably assessed

4.1 Manufacturing

The product is manufactured in accordance with the provisions of the European technical approval using the manufacturing process on the basis of agreed data/information -identified in the Control Plan and laid down in the Technical Documentation, deposited with Deutsches Institut für Bautechnik (DIBt), which identifies the product that has been assessed and judged.

Changes to the product or production process, which could result in this deposited data/information being incorrect, should be notified to the before the changes are introduced.

The Deutsches Institut für Bautechnik will decide whether or not such changes affect the approval and consequently the validity of the CE marking on the basis of the approval and if so whether further assessment or alterations to the approval shall be necessary.

4.2 Packaging, transport, storage of the product

The instructions related to

- Temporary protection of the connection-element in order to prevent cracking of concrete or damage during transportation from the production site to the job site,
- Storage and handling of the connection-element in order to avoid any cracking of concrete or damage,
- Protection of the connection-element from environmental influences which are the connection-elements not foreseen to be exposed of

are given in "Instruction for packaging, transport, storage and installation" Annex 6.

During transport and installation the specifications of the manufacturer shall be observed. It is the responsibility of the manufacturer of the product to ensure that the information on these provisions is given to those who are concerned.

4.3 Installation of the product in the works

It is assumed that the structure in which the connection-element is intended to be installed is designed according to EN 1992-1-1 and 1993-1-1, that all forces borne or transmitted by the connection-elements are properly transmitted to other structural members designed to resist this action-effect, using either European or national standards, but always applying good engineering practice.

The applicable national requirements and provisions of the Member State shall be taken into account at the place of use, if necessary.

The stability must be ensured in each case during installing the connection-element.

When installing the connection-element, the conditions for the installation in accordance with the installation instructions (see Annex 6) shall be met.

This installation instruction shall always be on hand when installing a connection-element on site.

4.4 Use, maintenance, repair

The assessment of the fitness for use is based on the assumption that maintenance is not required during the assumed intended working life.

It is the responsibility of the manufacturer of the product to ensure that the information on these provisions is given to those who are concerned.

5 Identification

5.1 Means of identification

The product which is the subject of the technical approval shall be identified by:

- Testing of product characteristics as laid down in Table 1.
- Reinforcement steel
- Dimensions (height, diameter)
- Material Number of structural steel
- Manufacturing process parameters
- Calculations, detailing, drawings

Table 1: Product characteristics, methods of verification and criteria used for checking the product identity

Number	Product characteristic	Verification method:	Criteria for product identity:
(1)	(2)	(3)	(4)
1	Concrete compressive strength	5.2.1.1	5.2.1.2
2	Reinforcement steel	5.2.2.1	5.2.2.2
3	Structural steel	5.2.3.1	5.2.3.2
4	Structural bolting assemblies	5.2.4.1	5.2.4.2
5	Dimensions (height, diameter, cross section A_c)	5.2.5.1	5.2.5.2

5.2 Product characteristics which are relevant for identification checking

5.2.1 Concrete

5.2.1.1 Method of verification

If necessary, concrete properties shall be tested at the product (i.e. concrete cores according EN-12504-1) or supplied samples in accordance to clause 2.1.2.1.

5.2.1.2 Criteria for product identity

Concrete properties shall comply with the design specification (accompanying product information) provided by the manufacturer.

5.2.2 Reinforcement steel

5.2.2.1 Method of verification

If necessary, reinforcing steel properties and amount shall be tested at supplied samples or samples taken from the product in accordance to clause 2.1.2.2).

5.2.2.2 Criteria for product identity

Number, diameter and strength shall comply with the design specification (accompanying product information) provided by the manufacturer.

5.2.3 Structural steel

5.2.3.1 Method of verification

Geometry and, if necessary, properties of structural steel shall be tested at the product or supplied samples in accordance to clause 2.1.2.3).

5.2.3.2 Criteria for product identity

Size, thickness and strength shall comply with the design specification (accompanying product information) provided by the manufacturer.

5.2.4 Structural bolting assemblies

5.2.4.1 Method of verification

Number, diameter, location and, if necessary, material properties shall be tested at supplied samples or samples taken from the product in accordance to clause 2.1.2.4.

5.2.4.2 Criteria for product identity

Number, diameter, location and strength shall comply with the design specification (accompanying product information) provided by the manufacturer.

5.2.5 Dimensions

5.2.5.1 Method of verification

Dimensions of the product (height, diameter, etc.) shall be tested.

5.2.5.2 Criteria for product identity

Geometry shall comply with the design specification (accompanying product information) provided by the manufacturer.

6 Reference List

EN 206-1:2000/A2:2005	Concrete - Part 1: Specification, performance, production and conformity;
EN 206-9:2010	Concrete - Part 9: Additional Rules for Self-compacting Concrete (SCC)
EN 1990:2002+A1:2005/AC:2010	Eurocode: Basis of structural design
EN 1992-1-1:2004+AC:2010	Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings;
EN 1992-1-2: 2004+AC:2008	Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design;
EN 1993-1-1:2005 + AC:2009	Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings;
EN 1993-1-2:2005 + AC:2009	Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design;
EN 10025-1:2004	Hot rolled products of structural steels -Part 1: General technical delivery conditions;
EN 10025-2:2004	Hot rolled products of structural steels -Part 2: Technical delivery conditions for non-alloy structural steels
EN 10025-3:2004	Hot rolled products of structural steels -Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels;
EN 10025-4:2004	Hot rolled products of structural steels -Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels;
EN 10025-5:2004	Hot rolled products of structural steels -Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance;
EN 10025-6:2004+A12009	Hot rolled products of structural steels -Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition;
EN 10204:2004	Metallic products - Types of inspection documents;
EN 12390-2:2009	Testing hardened concrete - Part 2: Making and curing specimens for strength tests;

EN 12390-3:2009	Testing hardened concrete - Part 3: Compressive strength of test specimens;
EN 12390-5:2009	Testing hardened concrete - Part 5: Flexural strength of test specimens;
prEN 12390-13: 2012	Testing hardened concrete - Part 13: determination of secant modulus of elasticity in compression;
EN 12843:2004	Precast concrete products Masts and poles;
EN 13369:2004/A1:2006	Common rules for precast concrete products;
EN 13225:2004	Precast concrete products - Linear structural elements;
EN 13501-1:2007+A1:2009	Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests;
EN 14399-1:2006	High-strength structural bolting assemblies for preloading - Part 1: General requirements;
EN 14399-4:2006	High-strength structural bolting assemblies for preloading - Part 4: System HV - Hexagon bolt and nut assemblies;
EN 15048-1:2007	Non-preloaded structural bolting assemblies - Part 1: General requirements;
EN 61400-1:2004	Wind turbines - Part 1: Design requirements (IEC 61400-1:2005 + A1:2010)
EN ISO 12944-1:1998	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 1: General introduction (ISO 12944-1:1998);
EN ISO 15630-1:2010	Steel for the reinforcement and prestressing of concrete - Test methods - Part 1: Reinforcing bars, wire rod and wire;
EN ISO 15630-3:2010	Steel for the reinforcement and prestressing of concrete - Test methods - Part 3: Prestressing steel;
EN ISO 17660-1:2006	Welding - Welding of reinforcing steel - Part 1: Load bearing welded joints;
EN ISO 17660-2:2006	Welding - Welding of reinforcing steel - Part 2: Non load bearing welded joints;
DASt-Richtlinie 021:2006	Schraubenverbindungen aus feuerverzinkten Garnituren M 39 bis M 64 entsprechend DIN 6914, DIN 6915, DIN 6916.

Andreas Kummerow
p. p. Head of Department

beglaubigt:
Dr. Moussa

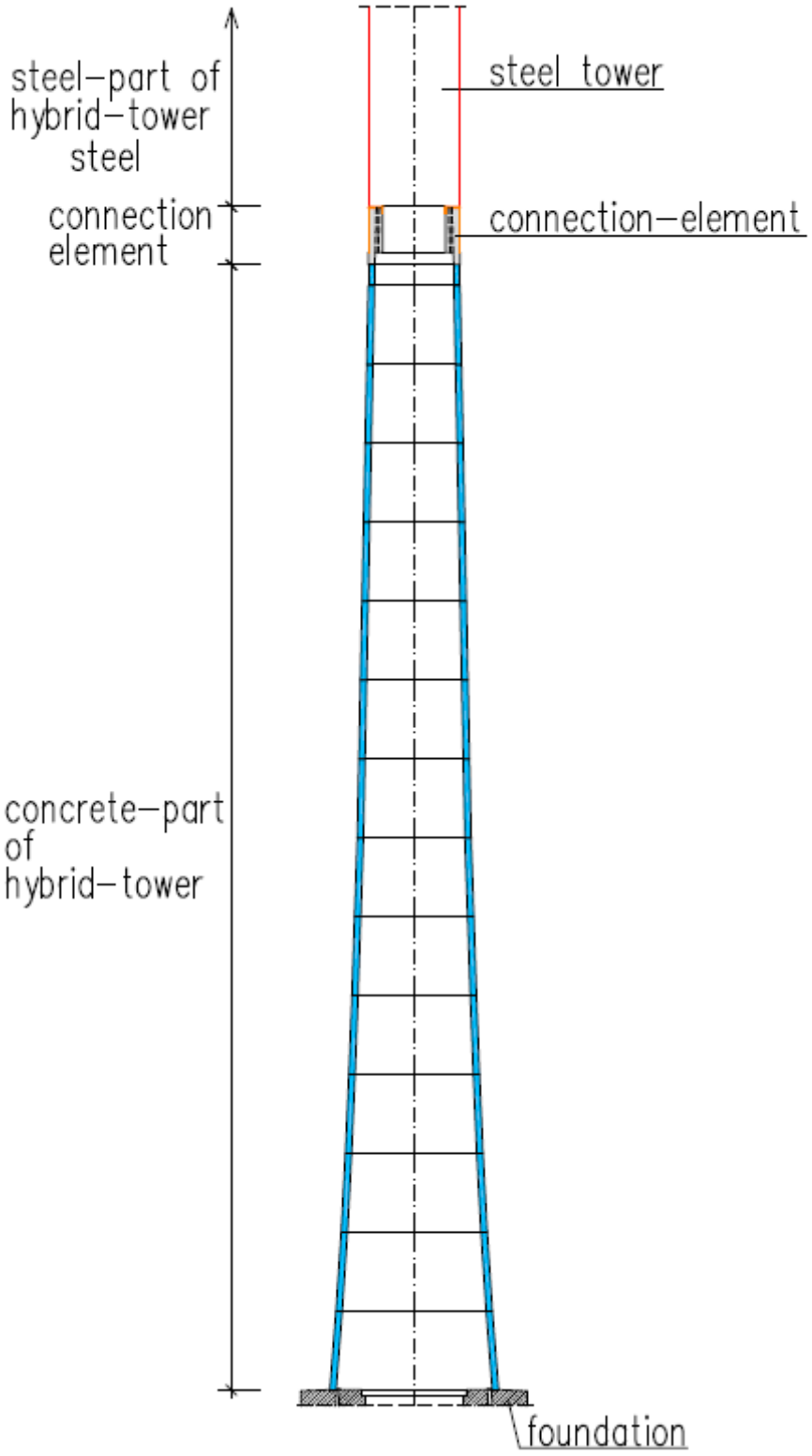

Figure 1: Longitudinal section hybrid tower

Prefabricated reinforced concrete connection-element for joining the steel- and concrete-part of hybrid-towers by use of prestressing without bond	Annex 1 Page 1/2
Longitudinal section hybrid tower	

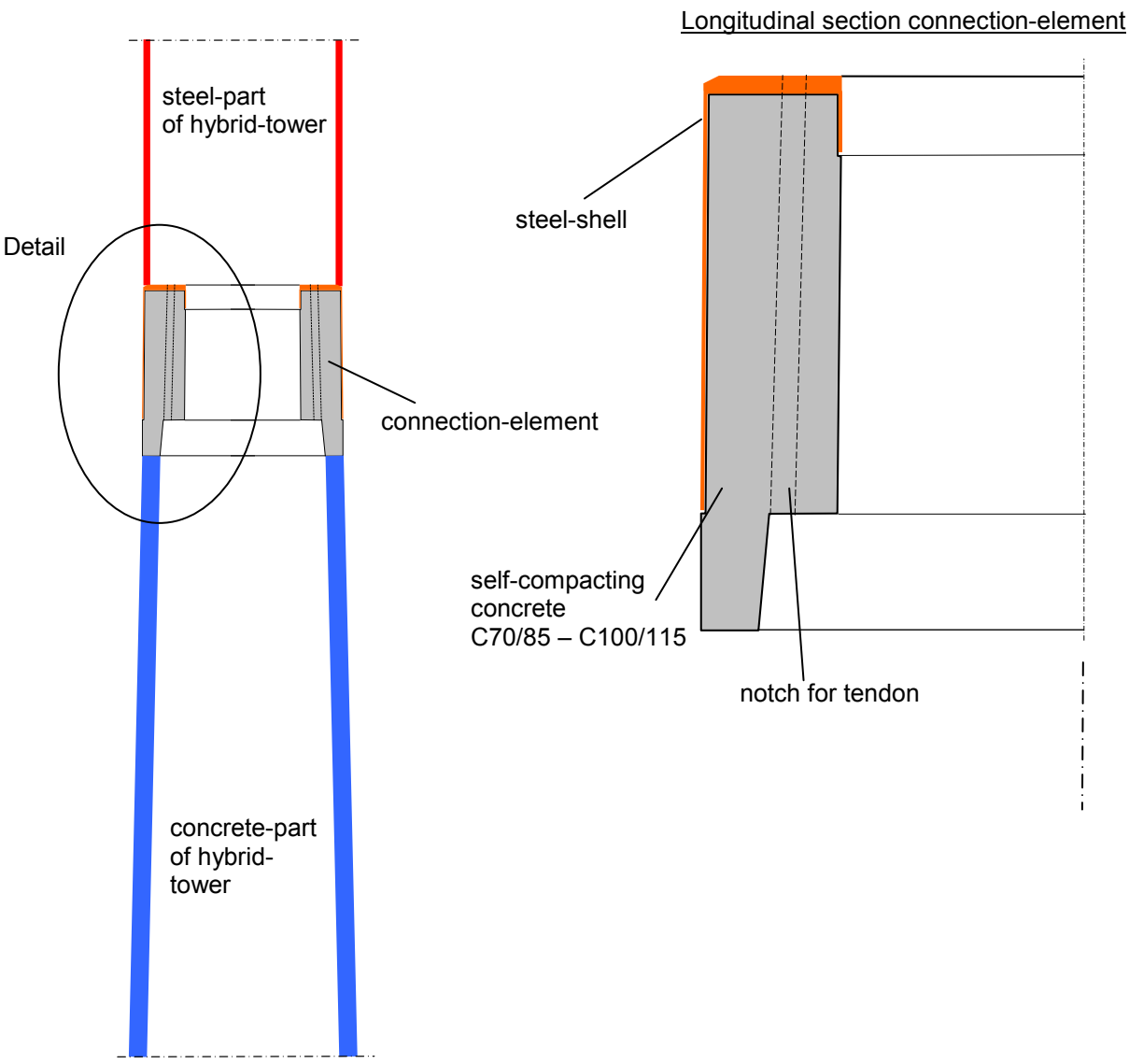

Figure 2: sketch of connection-element

Prefabricated reinforced concrete connection-element for joining the steel- and concrete-part of hybrid-towers by use of prestressing without bond	Annex 1 Page 2/2
Sketch of connection-element	

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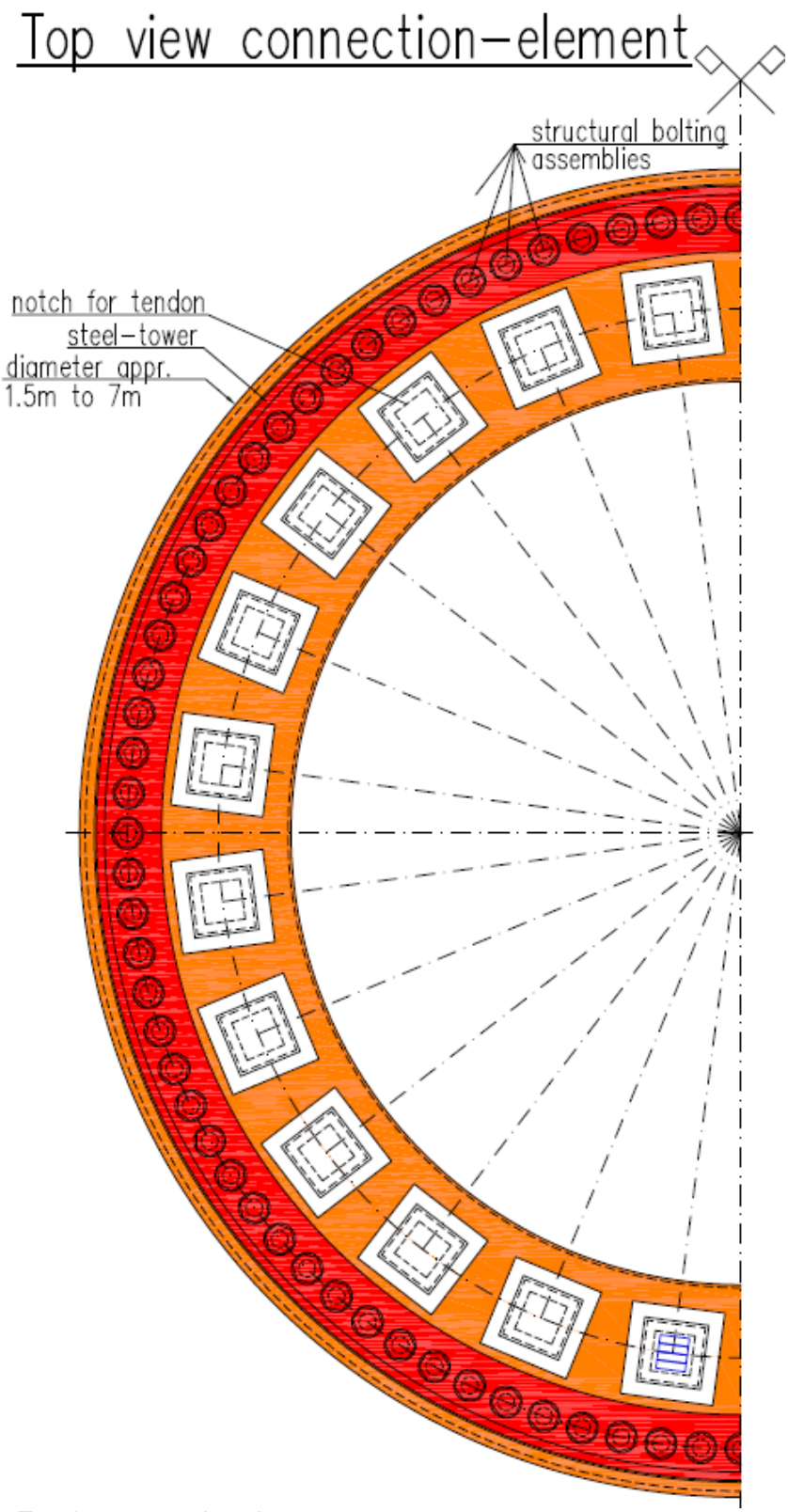

Figure 3: Topview connection element

Prefabricated reinforced concrete connection-element for joining the steel- and concrete-part of hybrid-towers by use of prestressing without bond	Annex 2 Page 1/2
Geometry of the connection element	

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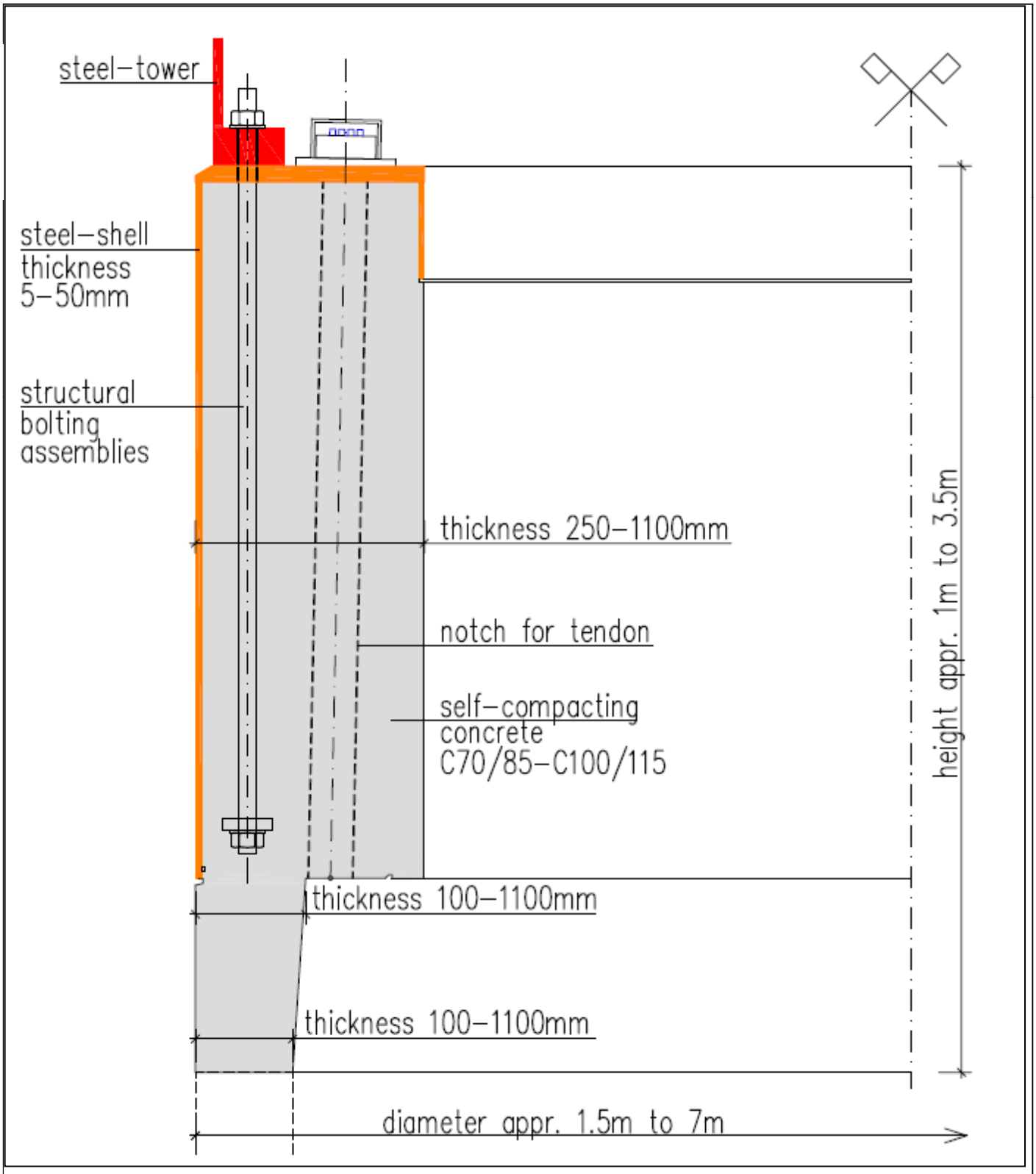

Figure 4: Detail connection element

Prefabricated reinforced concrete connection-element for joining the steel- and concrete-part of hybrid-towers by use of prestressing without bond	Annex 2 Page 2/2
Geometry of the connection element	

Deutsches Institut für Bautechnik DIBt

The concrete is self compacting concrete with a compressive strength in the range of C70/85 to C100/115 which shall be in accordance with EN 206-1 and EN 206-9.

For concrete with compressive strength class C70/85 to C100/115 in addition to the requirements of EN 206-1 and EN 206-9 the flexural tensile strength (tested on Prism: 150 x 150 x 700 mm) and for C100/115 also the modulus of elasticity shall meet the following requirements:

	C 70/85	C80/95	C90/105	C100/115
$f_{ctm,fl}$	≥ 8,5 N/mm²	≥ 8,9 N/mm²	≥ 9,3 N/mm²	≥ 9,6 N/mm²
$f_{ct,fl0,05}$	≥ 6,0 N/mm²	≥ 6,3 N/mm²	≥ 6,6 N/mm²	≥ 6,8 N/mm²
E_{cm}	According to EN 1992-1-1	According to EN 1992-1-1	According to EN 1992-1-1	≥ 45000 MN/m²

The composition of the concrete is laid down in the technical documentation deposited with Deutsches Institut für Bautechnik.

Prefabricated reinforced concrete connection-element for joining the steel- and concrete-part of hybrid-towers by use of prestressing without bond	Annex 3
Concrete properties	

Deutsches Institut für Bautechnik DIBt

Fatigue design shall be carried out according to the design method of CEB-FIP Model Code 1990 considering the following statements.

The following cases shall be distinguished:

a) Nominal number of Cycles $N_{nom} \leq 2 \cdot 10^9$:

For wind energy plants with a nominal number of cycles $N_{nom} = m \cdot n_R \cdot T_o \leq 2 \cdot 10^9$ with
m number of rotor blades
n_R nominal speed of rotation
T_o duration of action
design of the concrete in detail is not required if the condition specified in equation (1) is observed.

$$S_{cd,max} \leq 0{,}40 + 0{,}46 \cdot S_{cd,min} \qquad (1)$$

Where: $S_{cd,min} = \gamma_{Sd} \cdot \sigma_{c,min} \cdot \eta_c / f_{cd,fat}$
$S_{cd,max} = \gamma_{Sd} \cdot \sigma_{c,max} \cdot \eta_c / f_{cd,fat}$

$\gamma_{Sd} = 1{,}0$: Partial safety factor for acquiring the inaccuracies of the model for stress calculation

$\sigma_{c,max}$ Amount of the maximum concrete compressive stress under combinations of normal wind turbulence model (NTM), including default of signaling and control system or safety system as well as engine idle according to EN 61400-1:2004, section 6.3.1.3 and loads due to start and de-energisation as well as ice loads of normal wind profile model (NWP) according to EN 61400-1:2004, section 6.3.1.2.

$\sigma_{c,min}$ Amount of the minimum concrete compressive stress in the pressure zone at the same point where occurs, determined for the lower value of the action (tensile stresses

η_c Factor to take into account the uneven distribution of the concrete compressive stresses, simplified $\eta_c = 1{,}0$

$f_{cd,fat} = 0{,}85 \cdot \beta_{cc}(t) \cdot f_{ck} \cdot [(1 - f_{ck}/250)/ \gamma_c]$

Design value of the fatigue strength of concrete under compression stress

γ_c Partial safety factor for concrete according to EN 1992-1-1

$\beta_{cc}(t) = \exp [s \cdot (1 - (28/t)^{0,5})]$

Coefficient which depends on the age of concrete at the beginning of fatigue loading

s=0,20 for high strength cement with high initial strength

s=0,25 for cement with normal and higher initial strength

s=0,38 for cement with slow initial hardening

t concrete age in [days]

b) Nominal number of Cycles $N_{nom} > 2 \cdot 10^9$:

In this case the fatigue design follows the CEB-FIP Model Code 1990.

For both cases (a, b) the verification for fatigue shall be determined as follows:
The verification by means of a spectrum of load takes account of the required lifetime, the load spectrum (which is divided into *j* blocks) and the characteristic fatigue strength functions. Fatigue damage D is calculated by the Palmgren-Miner summation. Using the Rainflow method for counting, it has to be verified that the damage due to cyclic loads will not exceed the limit value of damage D_{lim}:

$$D = {}^{j}\Sigma_{i=1} (n_{Si}/N_{Ri}) \leq D_{lim} = 1$$

where
n_{Si} is the expected number of cycles during the required design service life
N_{Ri} is the number of resisting stress cycles, to be calculated from the S-N relations

The following S-N relations according to CEB-FIP Model Code 1990 should be used:
For $0 < S_{cd,min} < 0,8$

$$\log N_1 = (12 + 16 \cdot S_{cd,min} + 8 \cdot S_{cd,min}^2) \cdot (1 - S_{cd,max})$$

$$\log N_2 = 0,2 \cdot \log N_1 \cdot (\log N_1 - 1)$$

$$\log N_3 = \log N_2 \cdot (0,3 - \tfrac{3}{8} \cdot S_{Sd,min}) / \Delta S_{cd}$$

(a) If $\log N_1 \leq 6$, then $\log N = \log N_1$

(b) If $\log N_1 > 6$ and $\Delta S_{cd} \geq 0,3 - \frac{3}{8} S_{cd,min}$, then $\log N = \log N_2$

(c) If $\log N_1 > 6$ and $\Delta S_{cd} < 0,3 - \frac{3}{8} S_{cd,min}$, then $\log N = \log N_3$

where

$$S_{cd.max} = \gamma_{Sd} \cdot \sigma_{c,max} \cdot \eta_c / f_{cd,fat}$$

$$S_{cd.min} = \gamma_{Sd} \cdot \sigma_{c,min} \cdot \eta_c / f_{cd,fat}$$

$$\Delta S_{cd} = S_{cd,max} - S_{cd,min}$$

$\gamma_{Sd} = 1,0$ Partial safety factor for acquiring the inaccuracies of the model for stress calculation

η_c Factor to take into account the uneven distribution of the concrete compressive stresses, simplified

$\eta_c = 1.0$

γ_c Partial safety factor for concrete according to EN 1992-1-1

National rules for material fatigue design, which take into account the special conditions of the structure where the connection-element is incorporated or installed, can be considered as alternative.

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Where no national rules exist, the computation of the bursting reinforcement due to splitting tensile stresses has to be considered according to following procedure (see Figure 5).
The magnitude and position of the resulting splitting tensile force Z_S (as an integral of the stresses) can be determined with

$Z_s = 0{,}25 \cdot P \cdot [1 - (d_1/d_s)]$

where

Z_S	Resulting splitting tensile force
P	Compressive force, perpendicular to the subarea
d_1	Side length of the subarea
d_S	Side length of the distribution area

The resultant of additional tensile stresses at the edge can be approximately determined according to

$Z_R = P \cdot [(e/d) - (1/6)] \geq 0$

where

Z_R	Resulting tensile force
e	Distance of the point of load application to the center / axis of the total area
d	Side length of the total area

The center of the reinforcement has a distance of 0.05 d to the edge.

The further stress propagation of the longitudinal compressive stresses from the distribution area with the width d_s on the fully compressed zone in distance d of the loaded edge causes additional secondary transverse stresses.

The resultant force of these stresses can be approximately assumed as

$Z_{S2} = 0{,}3 \cdot Z_R$.

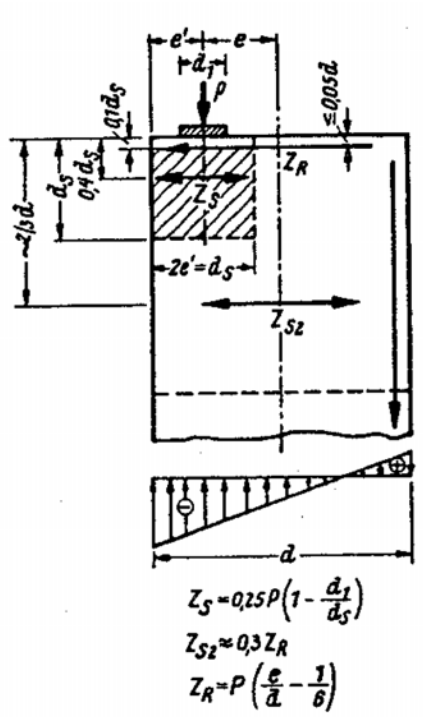

Figure 5: Tensile splitting forces and edge forces due to eccentric compressive load

Prefabricated reinforced concrete connection-element for joining the steel- and concrete-part of hybrid-towers by use of prestressing without bond	Annex 5
Splitting tensile force	

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Packaging, transport, storage and installation of the connection-element

1 General

This instruction includes:
- which general terms are valid for the package, transport and storage of the connection-element
- which general terms are valid for the lifting of the connection-element
- which additional items are needed to lift connection-element
- precautionary measures for the transport of the connection-element
- instruction of installation

2 Temporary protection of the connection-element in order to prevent cracking of concrete in the factory

The concreting of the connection-element is done within a weather protected hall. The connection-element will be covered by a PVC-foil for 2 day inside the hall. So the connection-element is protected from drying out. Thereby cracking in the concrete can be avoided during the hardening process.

3 Transport and Handling of the connection-element

The transport of the connection-element to the construction side is usually done by a road-transport. All necessary fixation tooling are exemplary mentioned in the following drawings. In addition the anchor bolts, which are on the top of the connection-element are protected by a PVC-tube during the transport.

Figure 6: Example for fixation tooling for the connection-element during the transport

Figure 7: Example for fixation tooling for the connection-element during the transport

4 Lifting/Installation of the connection-element

Another lifting process is needed for the connection-element between the concrete tower and the steel tower.
In this special case, there are no anchor points available on the prefabricated element, which are normally used for fixing the slippages.

Instead of that, slippages with a length of 7 meters will be pulled through two adjoining rectangular ducts; where later the tensile strands are located. The slippages will be put around a round wooden wedge. The both slippage endings, which are reaching out of the two openings on the upper edge of the adapter, have to be connected with a shackle, which has to have a load capacity of 25 tons at least. At this shackle, 9 meter slippages have to be fixed, which then also have to be fixed on the crane hook in order to lift the adapter on the tower.

Eight slippages are needed for the hub of the connection-element. Four, which will be pulled through the rectangular ducts and four, to fix onto the crane hook.

In every case one has to make sure, that an even distribution of the weight is made between the slippages. The positioning is at 0°, 90°, 180° and 270°.

5 Stability during installing

The stability and mechanical resistance must be ensured in each case during installing the connection-element.

Figure 8: Example for fixation of a slippage around a wooden wedge on the bottom edge of the connection-element

Figure 9: Upper edge of the adapter with implemented slippage

Prefabricated reinforced concrete connection-element for joining the steel- and concrete-part of hybrid-towers by use of prestressing without bond	Annex 6 Page 3/3
Packaging, transport, storage and installation of the connection-element	