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The implementation of the Eurocodes in the National Regulatory Framework

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Foreword

The construction sector is of strategic importance to the European Union (EU) as it delivers the buildings and transport infrastructure needed by the rest of the economy and society. It represents more than 9% of EU Gross Domestic Product (GDP) and more than 50% of the fixed capital formation. It is the largest single economic activity and it is the biggest industrial employer in Europe. The sector employs directly almost 18 million people. Construction is a key element not only for the implementation of the Single Market, but also for other construction relevant EU policies, e.g. Sustainability, Environment and Energy, since 40-45% of Europe's energy consumption stems from buildings with a further 5-10% being used in processing and transport of construction products and components.

The Eurocodes are a set of European standards which provide common rules for the design of construction works to check their strength and stability. In line with the EU's strategy for smart, sustainable and inclusive growth (EU2020), standardization plays an important part in supporting the industrial policy for the globalization era. The improvement of the competition in EU markets through the adoption of the Eurocodes is recognized in the "Strategy for the sustainable competitiveness of the construction sector and its enterprises" – COM (2012) 433[1], and they are distinguished as a tool for accelerating the process of convergence of different national and regional regulatory approaches.

With the publication of all the 58 Eurocodes Parts in 2007, their implementation in the European countries started in 2010 and now the process of their adoption internationally is gaining momentum. The Commission Recommendation of 11th December 2003[2] on the implementation and use of Eurocodes for construction works and structural construction products, stresses the importance of training in the use of the Eurocodes, which should be promoted in engineering schools and as part of continuous professional development courses for engineers and technicians. It is also recommended to undertake research to facilitate the integration into the Eurocodes of the latest developments in scientific and technological knowledge.

Since March 2005, the Joint Research Centre (JRC) of the European Commission provides scientific and technical support to the Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) in the frame of Administrative Arrangements on the Eurocodes. The activities of promotion of the construction sector outside the EU are part of the JRC effort to support the EU policies and standards for sustainable construction. In line with the Commission Recommendation of 11th December 2003, the JRC activities comprise guidance and training to the countries showing commitment to adopt and implement the Eurocodes and the European policies and tools for sustainable construction.

Among the countries that have shown commitment and progress in the adoption of the Eurocodes are the non-EU Balkan countries. The interest in the Eurocodes adoption and implementation in the Balkan region is based on the opportunity for an advanced common standardization environment, adaptable to the local requirements of each country (i.e. geographical, geological or climatic conditions) and allowing selection of the level of safety. Moreover, adoption and implementation of Eurocodes will help the Candidate Countries to fully implement EU acquis at the time of accession and support

[1] COM (2012) 433 final - COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL. "Strategy for the sustainable competitiveness of the construction sector and its enterprises". Brussels, 31 July 2012.

[2] 2003/887/EC - "Commission Recommendation 2003/887/EC of 11 December 2003 on the implementation and use of Eurocodes for construction works and structural construction products". Official Journal of the European Union, L332: 62-63.

Potential Candidate Countries (and Horizon 2020 associated countries) to progressively align with the EU acquis.

The JRC activities related to the Eurocodes implementation in the Balkans are aligned with EU's commitment to support the Western Balkan partners in view of democratic, political, economic and societal improvements and are contributing to the Action Plan set in COM (2018) 65 final[3]. The past and future Eurocodes related training activities support the Western Balkan countries and other non-EU countries in the Balkan region so as to build the capacities to adapt their own national legislation in the field of construction to the EU legal framework.

The present report contains a comprehensive description of the technical papers prepared by the lecturers of the Workshop "The way forward for the Eurocodes implementation in the Balkans". The Workshop was held on 10-11 October 2018, in Tirana, Albania, and was organized by the JRC, within the framework of the JRC Enlargement and Integration Action. The General Directorate of Standardization of Albania, CEN-CENELEC Management Centre and CEN/Technical Committee 250 "Structural Eurocodes" supported the organization of the workshop. The Workshop addressed representatives of National Authorities, National Standardization Bodies, Engineering Chambers, along with academics, Chairmen of CEN/TC250 Mirroring Committees and members of TC250 mirroring working groups. The Workshop aimed to assist non-EU countries in the Balkan region in the process of the Eurocodes full implementation in the national regulatory framework.

The report provides general information on the concept of the Eurocodes implementation in the regulatory system and discusses case studies of EU Member States that have successfully implemented the Eurocodes in their national regulatory system. It also highlights the experience of designers on using the Eurocodes by presenting simple application examples. Moreover, the state of the Eurocodes implementation in the non-EU Balkan countries is presented, based on the information exchanged and collected during the Workshop, along with the activities of the Engineering Chambers in support of the Eurocodes implementation. The way towards the publication of the Second Generation of the Eurocodes, expected after 2021, is also discussed.

We would like to gratefully acknowledge the workshop lecturers for their contribution and for sharing their experience and expert views.

The authors and editors have sought to present useful and consistent information in this report. The chapters presented in this report have been prepared by different authors, therefore are partly reflecting different practices in different countries. **Users of information contained in this report must satisfy themselves of is suitability for the purpose for which they intend to use it.**

The report, along with information and all the material prepared for the Workshop is available to download from the "Eurocodes: Building the future" website (https://eurocodes.jrc.ec.europa.eu/).

Ispra, February 2019

[3] COM (2018) 65 final - COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. "A credible enlargement perspective for and enhanced EU engagement with the Western Balkans". Strasbourg, 06.02.2018.

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This JRC report was prepared as a follow-up of the Workshop "The way forward for the Eurocodes implementation in the Balkans" on 10-11 October 2018 in Tirana, Albania. The Workshop was organized in the framework of the JRC Enlargement and Integration Action.

The editors would like to acknowledge the engagement of the participants, speakers and chairs of the Workshop for having shared their experiences and inspired interesting discussions and for contributing in the present document. The support provided by CEN/Technical Committee 250 "Structural Eurocodes" is particularly appreciated.

Abstract

The report provides general information on the concept of the Eurocodes implementation in the regulatory system and discusses case studies of EU Member States that have successfully implemented the Eurocodes in their national regulatory system. It also highlights the experience of designers on using the Eurocodes by presenting simple application examples. Moreover, the state of the Eurocodes implementation in the non-EU Balkan countries is presented, based on the information exchanged and collected during the Workshop "The way forward for the Eurocodes implementation in the Balkans" (10-11 October 2018 in Tirana, Albania), along with the activities of the Engineering Chambers in support of the Eurocodes implementation. The way towards the publication of the Second Generation of the Eurocodes, expected after 2021, is also discussed.

CHAPTER 1

THE CONCEPT OF THE EUROCODES IMPLEMENTATION

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1 The concept of the Eurocodes implementation

1.1 The Eurocodes within the European construction sector

1.1.1 The European construction sector

The construction sector is of strategic importance to many countries across the world as it delivers the buildings and infrastructure needed by the rest of the economy and society. In the European Union (EU), it is estimated that the construction sector generates about 9% of the Gross Domestic Product (GDP) and provides 18 million direct jobs. The construction sector is key element for the implementation of the Single Market and other construction relevant EU policies, e.g. Sustainability, Environment and Energy, since 40-45% of Europe's energy consumption stems from buildings with a further 5-10% being used in processing and transport of construction products and components.

The construction value chain includes a wide range of economic activities and plays an important role in achieving EU's "Europe 2020"[1] goals for smart, sustainable and inclusive growth. Buildings, infrastructure and construction products have an important impact on energy and resource efficiency, the environment in general and the fight against climate change. The EU strategy for the sustainable competitiveness of the construction sector[2] focuses on five objectives: investments, jobs, resource efficiency, regulation and market access[3].

Thus, the construction sector is at the heart of the European Energy Union Strategy[4], while the European Investment Plan[5] foresees that under the European regional and cohesion funds, considerable investments will be devoted to transport infrastructures and energy efficiency.

The EU has put in place a comprehensive legislative and regulatory framework for the construction sector, including corresponding European standards. Health and safety in construction and the free movement of engineering/construction services and products are important policy priorities. Concerning the construction activity itself, the focus is on the competitiveness of the sector, not least in the field of sustainable construction.

European legislation defines the essential requirements that goods must meet when they are placed on the market and the European standards bodies have the task of drawing up the corresponding technical specifications. The free movement of construction-related products and services is facilitated by the EU-wide implementation of common European

[1] https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester/framework/europe-2020-strategy_en

[2] COM (2012) 433. Strategy for the sustainable competitiveness of the construction sector and its enterprises.

[3] European Commission, The European construction sector: A global partner, 2016. http://ec.europa.eu/DocsRoom/documents/15866/attachments/1/translations/en/renditions/nativ.

[4] COM (2015) 80. A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy.

[5] COM (2014) 903. An Investment Plan for Europe.

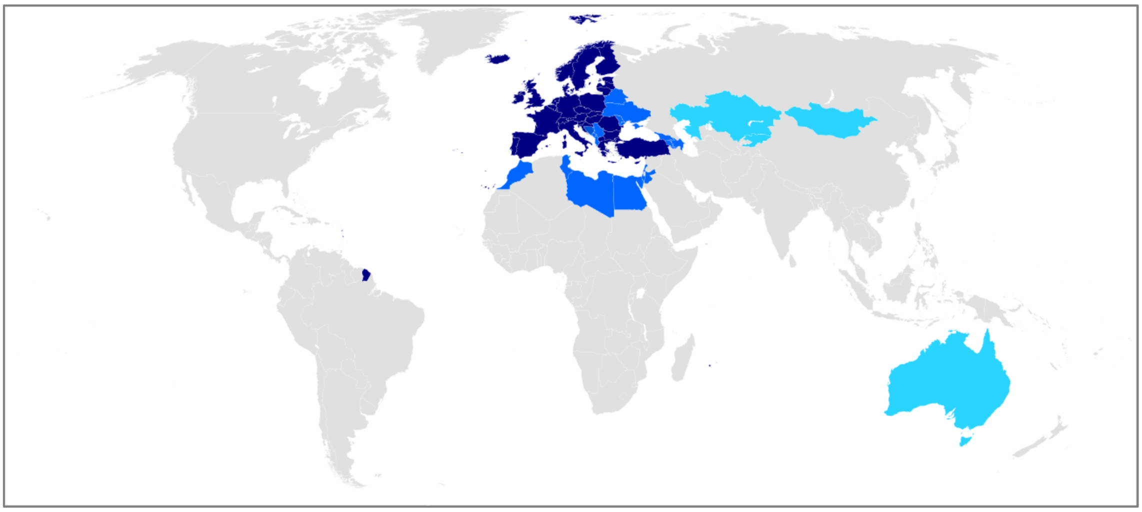
technical standards for the structural design of buildings and other construction works: the Eurocodes[6].

1.1.2 The European standards

A standard (French: norme, German: norm) is a document that provides rules, guidelines or characteristics for activities or their results, for common and repeated use[7]. Standards are technical specifications defining requirements for products, production processes, services or test-methods. These specifications are voluntary and they are developed by industry and market actors, following some basic principles such as consensus, openness, transparency and non-discrimination. Standards ensure interoperability and safety, reduce costs and facilitate companies' integration in the value chain and trade[8]. All interested parties through a transparent, open and consensus-based process develop them, codifying best practice that is usually state-of-the-art.

European Standards (Normes Européennes: EN) are developed under the responsibility of the European Standardisation Organisations (ESOs), namely: CEN (European Committee for Standardisation), CENELEC (European Committee for Electrotechnical Standardisation) and ETSI (European Telecommunications Standards Institute).

The National Standardisation Bodies (NSBs) of the 28 EU Member States (MS), three European Free Trade Association (EFTA) Member States (Iceland, Norway, and Switzerland), the former Yugoslav Republic of Macedonia, Serbia and Turkey, are National Members of CEN. The European Standards (ENs) published by CEN are developed by experts, established by consensus and adopted by the Members of CEN. The different types of CEN memberships are illustrated in Figure 1.1.



Members   Affiliates   Partner Standardisation Bodies

Figure 1.1 Members, affiliates, and partner Standardisation bodies of the European Committee for Standardisation (CEN) [© CEN-CENELEC]

[6] More information at the European Commission's official Eurocodes website: https://eurocodes.jrc.ec.europa.eu/

[7] https://www.cen.eu/work/products/ENs/Pages/default.aspx

[8] https://ec.europa.eu/growth/single-market/european-standards_en

Standards can be used to support EU legislation and policies. In line with the EU's strategy for smart, sustainable and inclusive growth (EU2020), Standardisation plays an important part in supporting the industrial policy for the globalization era. The benefits of standards, however, go far beyond that. In particular, the European Standards on construction:

- complete the internal market for construction products;
- create a transparent framework for competitiveness;
- make the free movement of engineering services a practical reality;
- transfer and disseminate technology;
- protect the health and safety of European citizens; and
- provide added value by reducing output and sales cost.

1.1.3 The Eurocodes and their links to EU policies and standards for the construction sector

The Eurocodes are a series of 10 European Standards, EN 1990 - EN 1999, providing a common approach for the design of buildings and other civil engineering works and construction products. They cover the basis of structural design, actions on structures and the design of concrete, steel, composite steel-concrete, timber, masonry and aluminium structures, together with geotechnical, seismic and structural fire design.

The European Commission has supported, from the very beginning in 1975, the development and elaboration of the Eurocodes, and contributed to the funding of their drafting. The publication of the Eurocodes by CEN in May 2007 marked a major milestone in the European standardisation for the construction sector, since the Eurocodes introduced common technical rules for calculating the mechanical and fire resistance, and the stability of constructions and construction products. The implementation of the Eurocodes in the EU and EFTA Member States enhances the functioning of the internal market for construction products and services by removing the obstacles arising from different national practices.

The improvement of the competition in EU markets through the adoption of the Eurocodes is recognized in the "*Strategy for the sustainable competitiveness of the construction sector and its enterprises*" – COM (2012) 433. The Eurocodes are distinguished as a tool for accelerating the process of convergence of different national and regional regulatory approached.

The Eurocodes are the recommended means of giving a presumption of conformity with the basic requirements of the Construction Products Regulation (CPR)[9] for construction works and products that bear the CE Marking, in particular Basic Requirement 1 "*Mechanical resistance and stability*" and Basic Requirement 2 "*Safety in case of fire*". The objective of the CPR is to achieve the proper functioning of the internal market for construction products by establishing harmonised rules on how to express their performance.

Further, the Eurocodes are the preferred reference for technical specifications in public contracts as, according to the Public Procurement Directive[10], contracting authorities in

[9] Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC OJ L 88 of 4 April 2011.

[10] Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC Text with EEA relevance.

the EU must allow the use of the Eurocodes for the structural design aspects of tenders. The Eurocodes are the standard technical specification, for all public work contracts in the EU and EFTA countries. When a designer is proposing an alternative design, it must be demonstrated that it is technically equivalent to a design solution by the Eurocodes.

EU Recommendations and Opinions are not binding but express the Council's or Commission's view on policy to the Member States or to the individuals to which they are addressed. Whilst Recommendations and Opinions are not legally binding, they allow the institutions to make their views known and to suggest a line of action. In the Commission Recommendation 2003/887/EC[11] on the implementation and use of Eurocodes for construction works and structural construction products, the European Commission recommends that Member States should:

- Adopt the Eurocodes as a suitable tool for designing construction works, checking the mechanical resistance of components, or checking the stability of structures.
- Lay down the Nationally Determined Parameters (NDPs)[12] usable in their territory.
- Use the recommended values of the NDPs provided by the Eurocodes.
- Compare the NDPs implemented by each Member State and assess their impact.
- Refer to the Eurocodes in their national provisions for conformity assessment.
- Undertake research to facilitate the integration into the Eurocodes of the latest developments in scientific and technological knowledge.
- Promote instruction in the use of the Eurocodes.

The European Standardisation system relating to the construction sector is a comprehensive system of design standards that comprises the Eurocodes, along with material and product standards, as well as execution and test standards (see Figure 1.2). Thus, for the design and construction of buildings and other civil engineering works, the Eurocodes are intended to be used in combination with execution, material, product and test standards. This set of standards covers all aspects of construction, namely design rules, material properties, execution of structures and special works, specifications for construction products, as well as quality control.

Figure 1.2 The European Standards family for the construction sector

[11] Commission Recommendation of 11 December 2003 on the implementation and use of Eurocodes for construction works and structural construction products.

[12] The Eurocodes recognise the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at a national level where these continue to vary from State to State. The Eurocodes provide for National Choices full sets of recommended values, classes, symbols and alternative methods to be used as Nationally Determined Parameters (NDPs).

1.2 The national implementation of the Eurocodes

The CEN-CENELEC Internal Regulations[13] specify the following two steps to be performed by the CEN National Members for the implementation of any European Standard (EN), thus also for the Eurocodes, at national level by giving them the status of National Standard:

- publication of an identical text or endorsement in 6 months after the date of availability; or
- withdrawal of any National Standards conflicting with the EN in 6 months after the date of availability.

The implementation of a Eurocode Part has three phases, namely the Translation Period, the National Calibration Period and the Coexistence period. The periods are relative to the date when CEN has delivered the Eurocode Part(s) to the National Standards Body (Date of Availability – DAV). Thus, the Member States' National Authorities in liaison with the National Standards Bodies (NSBs) and other relevant parties, should design and set-up an appropriate Implementation Plan for the Eurocodes in their country. As part of that plan, when a Eurocode Part is made available, National Authorities and National Standards Bodies should:

- translate the Eurocode Part in authorised national languages; it is noted that all Eurocode Parts were published by CEN in three languages: English, French and German;
- set the NDPs to be applied on their territory;
- publish the National Standard transposing the Eurocode and the National Annex, containing the national choice on the NDPs and reference to non-contradictory complementary information (NCCI)[14], and notify the European Commission;
- adapt, as far as necessary, their National Provisions so that the Eurocode Part can be used on their territory: (i) as a means to prove compliance of construction works with the national requirements for "mechanical resistance and stability" and "resistance to fire" and (ii) as a basis for specifying contracts for the execution of public construction works and related engineering services;
- promote training on the Eurocodes.

During the Coexistence Period, both the National Standard transposing the Eurocode and any existing national standard can be used. At the end of the Coexistence Period of the last Eurocode Part of a package, the National Standards Body should withdraw all conflicting National Standards.

The National Standard transposing the Eurocode Part, when published by a NSB, is composed of the Eurocode text (preceded by a National Title page and by a National Foreword), generally followed by a National Annex. The NSBs should normally publish a National Annex, on behalf of and with the agreement of the national competent authorities.

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[13] CEN-CENELEC Internal Regulations – Part 2:2015.

[14] The National Annex may contain references to non-contradictory complementary information to assist the user to apply the Eurocode. This possibility gives limited scope to provide explanation of a clause, perhaps in comparison with existing national rules. The provision of other material should be in documentation separate from the National Annex, whether endorsed by a national competent authority or published independently.

The Eurocodes recognise the responsibility of regulatory authorities in each Member State and have safeguarded their right, to determine values related to regulatory safety matters at a national level where these continue to vary from State to State. Thus, the Eurocodes provide for national choices full sets of recommended values, classes, symbols and alternative methods to be used as Nationally Determined Parameters (NDPs). Countries implementing the Eurocodes should lay down their NDPs and should:

- choose from the classes included in the Eurocodes, or
- use the recommended value, or choose a value within the recommended range of values, for a symbol where the Eurocodes make a recommendation, or
- when alternative methods are given, use preferably the recommended method, where the Eurocodes make a recommendation; and
- take into account the need for coherence of the NDPs laid down for the different Eurocodes and the various parts thereof.

Information on the NDPs to be used for the design of buildings and other civil engineering works to be constructed in the country concerned are contained in the National Annex (NA) to a given Eurocode Part. Thus, the National Annex contains:

- values and/or classes where alternatives are given in the Eurocode;
- values to be used where a symbol only is given in the Eurocode;
- country specific data (geographical, climatic, etc.), e.g. snow map;
- procedure to be used where alternative procedures are given in the Eurocode;

The National Annex to a Eurocode Part may also contain:

- decisions on the application of informative annexes, and
- references to non-contradictory complementary information to assist the user to apply the EN Eurocode.

Voluntary application of standards is one of the founding principles of the European Standardisation[15]. However, the national legislative provisions may refer to standards making the compliance with them compulsory. Thus, in relation to the implementation procedure of the Eurocodes Parts, it is important to stress that the regulatory environment in each country is very important. In the different regulatory environments, the national regulations either refer to standards - thus making the compliance with them compulsory- or introduce directly a set of design rules. In the latter case, no National Standards exist, and hence there is no need to withdraw conflicting standards. Contrary, there are countries where the rules for structural design are enforced by legislative acts, i.e. national regulations.

1.3 State of Eurocodes implementation in the EU

The state of the Eurocodes implementation in the EU by 2015 has been presented in the JRC Report "*State of Implementation of the Eurocodes in the European Union*"[16]. The report represents the results of the enquiry on the implementation of the Eurocodes in the EU Member States and Norway, which was performed by DG GROW[17] and JRC of the

[15] Regulation (EU) 1025/2012 on European standardisation.

[16] Dimova S., Fuchs M., Pinto A., Nikolova B., Sousa L., Iannaccone S.; State of implementation of the Eurocodes in the European Union; EUR 27511 EN; doi:10.2788/353883.

[17] Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW)

European Commission in 2014-2015. The enquiry primarily aimed to establish the state of implementation of the Eurocodes in the EU Member States in their specific regulatory and standardisation environment and, in parallel, determine the place of the Eurocodes in Public Procurement. Further, the data collected through the survey was used to detect potential barriers, which restrict or impede the implementation of the Eurocodes and gather comments regarding experience accumulated in the implementation of the Eurocodes, problems encountered and solutions found.

The results showed that the Eurocodes were already accepted as National Standards in Europe by 2015, as shown in Figure 1.3. All EU Member States and Norway had published all Eurocode Parts as National Standards, except Germany and Luxembourg (that did not publish one part) and Spain (which published or ratified 83% of the Eurocode Parts). Thus, it was evident in 2015 that the Eurocodes were already accepted as National Standards in the EU MS.

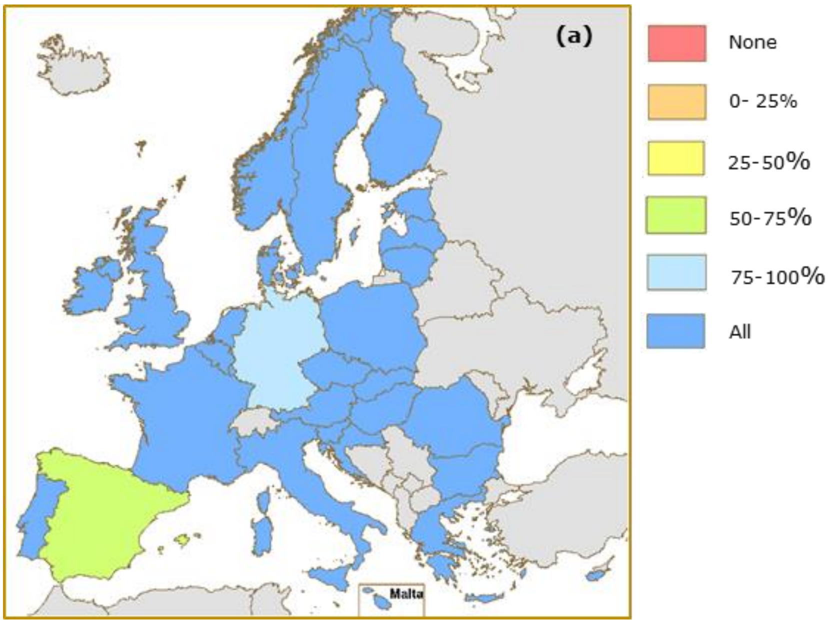

Figure 1.3 Publication of National Standards on the Eurocodes in percentage of all Parts (Athanasopoulou et al., 2018)

In three out of four countries, more than 80% of the published Eurocodes Parts were available in the National Language or in one of the official National Languages (at the time the survey was performed). Moreover, 90% of the considered in the analysis countries published National Annexes to more than 70% of all Eurocodes Parts.

As already discussed, when the CEN National Members are implementing an EN standard, they shall withdraw any National Standards conflicting with it. In 80% of the countries included in the analysis, no National Standards were used in parallel with the Eurocodes Parts, as shown in Figure 1.4. However, this very positive result shall be considered having in mind the regulatory environment in some EU Member States, where the rules for structural design are enforced by national regulations, in which case no National Standards exist, and hence – there is no need to withdraw conflicting standards. As example of countries, where there are no conflicting standards, but the existing national regulations introduce directly design rules which do not fully reflect the entire set of the Eurocodes provisions, one can mention Italy, Portugal, Romania, and Spain. There are also countries, where the national regulations allow the parallel use of the Eurocodes and other standards or Regulations, as is the case of:

- Bulgaria, where for new construction works of third, fourth and fifth category (e.g. family houses) not assigned under Public Procurement, it is allowed to use either the Eurocodes or the existing National Regulations for design of building structures, without mixing the methods of calculation and design.
- Greece, where the Owner/Authority has to choose the framework of regulatory documents for structural design: either, the pre-existing regulatory documents, or, the Eurocodes together with their National Annexes.
- Latvia, where National Regulations are used in parallel with Parts of EN 1990, EN 1991, EN 1992, EN 1995 and EN 1996. No National Regulations are used in parallel with EN 1994.
- Lithuania and Luxembourg, where there are National Regulations on structural design, which may be used in parallel with the Eurocodes.
- Poland, where National equivalents of the Eurocodes have status of withdrawn standards. However, other National Standards were used in parallel with 70% of the Eurocodes Parts, posing similar or additional requirements.

In Ireland, guidelines are used as non-contradictory complementary information to seven Eurocodes Parts. The answer by the Irish NSB also specified that the National Annex to IS EN 1992-1-1 refers to the National Annex of IS EN 206.

In Germany, National Standards are used in parallel with EN 1991-4 (DIN FB 140), with EN 1995-1-1 (DIN 1052-10), and with EN 1997-1 (DIN 1054). In these cases, the National Regulations and "DIN Fachbericht" complement the Eurocodes Parts.

In Slovakia three National Standards are used in parallel with EN 1997-1 as complementary documents.

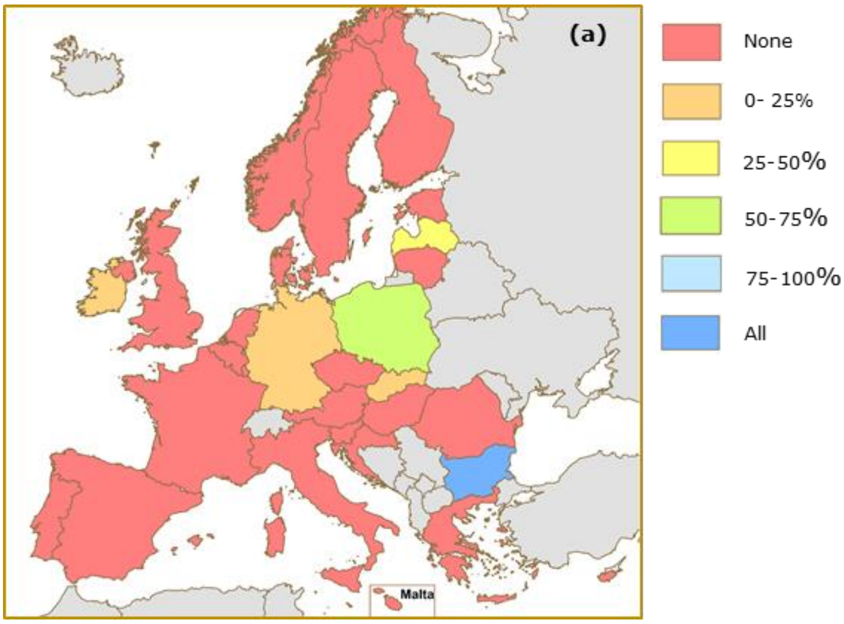

Figure 1.4 Rate of use of National Standards in parallel with the Eurocodes Parts (Athanasopoulou et al., 2018)

Even if the voluntary application of standards is one of the founding principles of the European Standardisation, National legislative provisions may refer to standards making the compliance compulsory, as presented in Section 1.2. In more than half of the analysed countries, the National legislative provisions referred to standards and, in many cases, made compliance with them compulsory (see Figure 1.5). More than half of the analysed countries (55%) declared that none of the Eurocodes Parts is obligatory, where as in 10% of the countries all Eurocodes Parts are obligatory, and in 35% of the countries different amount of Eurocodes Parts (varying between 6 and 46) is obligatory.

The results above show clearly two main approaches in the National implementation of the Eurocodes: as voluntary National Standards and via a Regulatory Framework, which encompasses different amount of Parts in the different countries.

As regards the need of amendment of the National Regulations to allow use of the Eurocodes:

- 41% of the analysed countries reported that no amendment was needed,
- in 14% of the countries amendment was needed (or would be needed at the time of the survey – in Portugal and Spain) for less than 40% of the Eurocodes Parts,
- and in 45% of the countries amendment was needed for more than 40% of the Eurocodes Parts.

Restrictions were posed by references to non-contradictory complementary information in Ireland, or by special conditions for the application of some general methods of calculation in Germany. In Italy and Romania the regulatory environment posed considerable restrictions to the implementation of the Eurocodes.

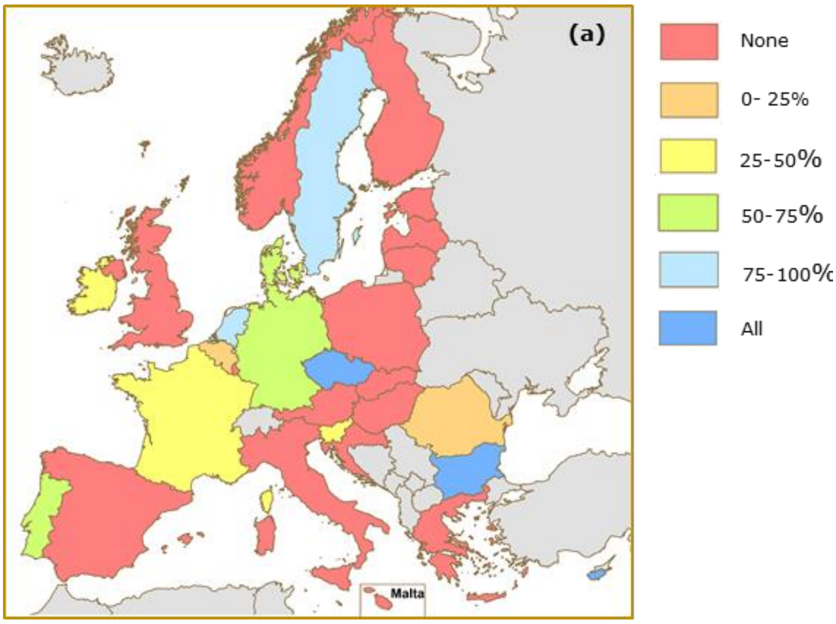

Figure 1.5 Rate of obligatory Eurocodes Parts as percentage of all Parts (Athanasopoulou et al., 2018)

Regulatory Framework enforcing the use of the Eurocodes in Public Procurement existed (or was foreseen to be implemented) in 41% of the analysed countries; another 17% of the countries considered that the Eurocodes are well-placed in the Public Procurement without having a particular Regulatory Framework. Thus 60% of the analysed countries reported a good place of the Eurocodes in Public Procurement at national level.

1.4 Commentary on the countries which are discussed as case studies in following chapters

The information below presents the situation of the countries discussed as case studies in Chapter 3. The information provided below is as reported in the JRC report "*State of the implementation of the Eurocodes in the European Union*" (JRC, 2015).

1.4.1 Belgium

At the time of the survey, all Eurocodes Parts were published as National Standards. They are available in French and Flemish. The use of the Eurocodes is voluntary, as generally is the state of the standards in Belgium. The Civil Code considers that the designers are obliged to follow the "rules of the art", which include generally the available National Standards.

There is an exception for fire safety: if the designer uses calculations to justify the fire safety, the use of the Eurocodes Parts relevant to fire safety (except for aluminium structures) was made mandatory by the Ministerial Decree of May 17, 2013 "M.D. 17/5/2013" as an amendment of the preceding situation. Another exception is the design of football stadiums, for which EN 1990 was made mandatory (Ministerial Decree of July 6, 2013).

No other National Standards are used in parallel and there are no special provisions for the enforcement of the Eurocodes in the Public Procurement. National Annexes are published on all Eurocodes Parts in French and Flemish and no translation in English is available.

As regards the Public Procurement, the public authorities write traditionally in their contracts that "*all National Standards available at NBN* [i.e. the Belgian National annexes] *are applicable*", so the Eurocodes are automatically included as a referenced standards for the contracts. The most important authorities use also more detailed prescriptions, enforcing the use of the Eurocodes for infrastructure works and important buildings.

1.4.2 Bulgaria

All Eurocodes Parts have been published as National Standards and translated in the National Language. According to the Law on the National Standardisation, the application of the Eurocodes standards is voluntary in general. As far as the structural design concerns the citizen's health and safety, it is obligatory to introduce the Structural Eurocodes or Parts of them through National Ordinances. Ordinance № RD-02-20-19 of 29 December 2011 (effective as of 6 January 2012) defines the conditions and procedure for the structural design of construction works or of parts thereof by using the Eurocodes. It is noted that the Bulgarian reply to the Eurocodes implementation enquiry did not consider the act as amendment of the relevant National Regulations.

From 6 January 2014, the use of the Eurocodes is obligatory for the design of new construction works for contracts awarded under the Public Procurement Act (Ordinance amending Ordinance № RD-02-20-19 of 29 December 2011, Gazette, n. 111 from 2013).

From 6 January 2015, the use of the Eurocodes is obligatory for the design of new construction works of first and second category, where the categories are specified in Article 137 of the Spatial Development Act. For new construction works of third, fourth and fifth category, which are not assigned under the Public Procurement Act, the design can be made with the Eurocodes or with the existing National Regulations for the design of building structures, without mixing the methods of calculation and design.

National Annexes are published to all Eurocodes Parts except to EN 1997-2 and they are all translated in English and uploaded on the JRC NDPs Database. All National Annexes in Bulgarian are available free of charge on BDS website[18], and on the website of Ministry of Regional Development and Public Works[19].

1.4.3 Croatia

All Eurocodes Parts have been published as National Standards. They are translated in the National Language, except the EN 1990 series. The use of the Eurocodes is not obligatory. The designer has a choice to use any other specification or scheme in order to give evidence that Basic Works Requirement "Mechanical Resistance and Stability" of the CPR is fulfilled. However, the result must be at least as safe as if the Eurocodes were used. Since there is no other national scheme available, the consequent result is that in practice the use of the Eurocodes is similar to the case when they would be obligatory. Moreover, no other National Standards are used in parallel with the Eurocodes.

National Annexes are published on all Eurocodes Parts except EN 1997-2. The published National Annexes are available in English, except those to EN 1991, EN 1992 and EN 1993 series.

Regarding Public Procurement, the National legislation refers to the "*National Standards which are adopted European Standards*", although, there is no specific reference to the Eurocodes.

1.4.4 Czech Republic

All Eurocodes Parts are published as National Standards and translated in the National language. The National Regulation 268/2009 on buildings makes reference to the NDPs (standardised values) providing the list of Eurocodes in its Annex. The National Regulation 104/1997 (Amendment 2011) for road bridges and SZDC regulations for railways make reference to valid National Standards.

Eurocodes are obligatory means for structural design. There are no other National Standards used in parallel with the Eurocodes. National Annexes are published to all Eurocodes Parts and all National Annexes are translated in English.

Law 137/2006 on Public Procurement is the Regulatory Framework for enforcing the use of the Eurocodes in Public Procurement.

The Czech experience in the implementations of the Eurocodes shows that in case of need, several Czech State Institutions have helped to solve the problem; further the co-operation with CEN/TC 250 was deemed very helpful.

[18] www.bds-bg.org

[19] www.mrrb.government.bg

1.4.5 France

All Eurocodes Parts are published as National Standards in French language. The 22 Eurocodes Parts which are obligatory, are those related to the French ordinances for fire resistant and seismic resistant design, i.e.

- Arrêté du 16 mars 2011 sur la résistance au feu;
- Arrêté du 22 octobre 2010 modifié sur la construction parasismique;
- Arrêté du 24 janvier 2011 parasismique;
- Arrêté du 19 juillet 2011 parasismique;
- Arrêté du 26 octobre 2011 parasismique ponts.

No other National Standards are used in parallel with the Eurocodes. There are no restrictions to the use of the Eurocodes Parts. No National Annexes are published on 8 Eurocodes Parts (2 on EN 1993, 1 on EN 1997 and 5 on EN 1999). The published National Annexes are not available in English.

There is no particular Regulatory Framework in enforcing the use of the Eurocodes in Public Procurement.

1.4.6 Greece

All Eurocodes Parts are published as National Standards and translated in the National Language. At the time of the enquiry in 2015, the Eurocodes were not obligatory in Greece. A Ministerial Decision had been drafted rendering the use of existing national regulatory documents non-mandatory and allowing the use of Eurocodes as an alternative option, which is the common practice in the case of Public Procurements. The "Common Ministerial Decision" DIPAD/372/30-05-2014 (Official Government Gazette 1457 B/05-06-2014) implies that:

- the Eurocodes in combination with the relevant National Annexes may be used as regulatory documents for the design of new and the assessment and redesign of existing structures, both for public and private (civil engineering) works;
- pre-existing National Codes/Regulations are no more mandatory;
- the Owner/Authority has to choose the framework of regulatory documents for structural design between the two following options: either, the pre-existing regulatory documents, or, the Eurocodes together with their National Annexes;
- a selective use of clauses from both regulatory systems is prohibited.

National Annexes are published to all Eurocodes Parts; at the time the survey was conducted, there was no official translation in English.

It is also worth mentioning that the Code of Structural Interventions (Final Harmonized Text, August 2012), ("ΚΑΝ.ΕΠΕ" in Greek) is applied in parallel with EN 1998-3 as non-contradictory complementary information.

There is no specific Regulatory Framework enforcing the use of the Eurocodes in Public Procurement. However, Public Authorities may allow or enforce the use of the Eurocodes in the tender documents for structural design for the construction projects and this is the common practice.

1.4.7 The Netherlands

All Eurocodes Parts are published as National Standards and 33 Parts are translated in the National Language. All Eurocodes Parts, except EN 1991-1-6 and EN 1998 series are obligatory means for structural design enforced by separate Decision (Bouwbesluit) for each part. The same Decisions enforce the use of the Eurocodes Parts in Public Procurement. There are no other National Standards used in parallel with the Eurocodes.

No National Annexes are published on nine Eurocodes Parts (one on EN 1993, six on EN 1998 series and two on EN 1999) and 14 National Annexes are available in English. All National Annexes are included in the building regulations.

1.5 Use of the Eurocodes in third countries

There is a considerable interest in the use of Eurocodes outside EU by countries:

- whose National Standards are based on European or National Standards that will soon be withdrawn;
- who want to update their National Standards based on technically advanced codes;
- who are interested in trading with the European Union and EFTA Member States.

The Eurocodes may be used for the above purposes, because they are:

- a complete set of design standards that cover in a comprehensive manner all principal construction materials, all major fields of structural engineering and a wide range of types of structures and products;
- the most up-to-date codes of practice;
- flexible, offering the possibility for each country to adapt the Eurocodes to their specific conditions regarding climate, seismic risk, traditions, etc. through the NDPs. NDPs can also be adapted to the national approach and setup regarding risk and safety factors.

With regards to the exploitation rights of all EN standards, it is CEN and its members who own the copyright. A clear distinction is made within the CEN rules between two types of use for the EN standards:

- adoption of ENs as National Standards of the country concerned (and the withdrawal of any other National Standards that conflict with them), or
- publication of the ENs without adoption.

CEN supports any actions aimed at disseminating the results of its work and encourages the adoption of European Standards as National Standards in countries outside the CEN area. Use of European Standards is subject to an agreement signed by CEN and the country that wishes to use the standards. CEN-CENELEC Guide 10[20] establishes the agreed policy for the distribution and sales of CEN-CENELEC publications. CEN/CENELC Guide 12[21] describes the concept of affiliation with CEN and CENELEC and CEN/CENELC Guide 13[22] presents the concept of a Companion Standardisation Body. Lastly,

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[20] CEN-CENELEC Guide 10 "Policy on dissemination, sales and copyright of CEN-CENELEC Publications".

[21] CEN-CENELEC Guide 12 "The concept of affiliation with CEN and CENELEC".

[22] CEN-CENELEC Guide 13 "The concept of a Companion Standardisation Body with CEN and CENELEC".

CEN/CENELC Guide 30[23] is a reference document on Standards and Regulation aimed primarily at public authority policy makers.

Interested National Standards Bodies should address CEN and in particular, the Programme Manager for Industry, Technology and Infrastructure whereas interested National Authorities should contact the European Commission, i.e. DG GROW The contact details are provided in the Eurocodes website of the European Commission[24].

Moreover, the European Commission is engaged in activities for the promotion of the Eurocodes, and the construction sector in general, outside the EU as part of its efforts to support the EU policies and standards for sustainable construction. In line with the Commission Recommendation of 11th December 2003, the JRC activities comprise guidance and training to the countries showing commitment to adopt and implement the Eurocodes and the European policies and tools for sustainable construction.

JRC collects, assesses and disseminates up-to-date information on the international status of Eurocodes adoption in partnership with relevant Directorates-General of the European Commission such as DG GROW, DG DEVCO[25], DG NEAR[26]/TAIEX[27], EEAS[28], CEN-CENELEC, National Standards Bodies, EU Member States, and individual experts. The JRC Europe Media Monitor (EMM) tool[29] also facilitates the identification of news relevant to the Eurocodes. Information collected by the JRC includes expression of interest on the Eurocodes by third countries, planned and performed dissemination activities, needs and implementation progress in countries of interest. The status of worldwide interest in the Eurocodes is visualised in the Eurocodes map, provided in Figure 1.6.

Moreover, JRC with support from relevant stakeholders has been producing and publishing a variety of open-source training material in support of the dissemination and use of the Eurocodes in third countries, including the following:

- Reports with worked examples (e.g. on Eurocode 8 for the seismic design of buildings);
- Background documents;
- Pre-normative material on the 2nd generation of the Eurocodes;
- Presentations from training workshops;
- Promotion material (leaflets, booklets) (e.g. The European construction sector –A global partner.

All the above training and more than 500 Eurocodes-related publications (or their full references to them) can be found in the Publications Database of the European Commission's Eurocodes Website[30]. The Database currently contains references to publications in 16 different languages and it is searchable by Eurocode and language.

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[23] CEN-CENELEC Guide 30 "European Guide on Standards and Regulation – Better regulation through the use of voluntary standards – Guidance for policy makers".

[24] For contact information, see at :https://eurocodes.jrc.ec.europa.eu/showpage.php?id=8

[25] DG DEVOC - Directorate-General for International Cooperation and Development.

[26] DG NEAR - Directorate-General for Neighbourhood and Enlargement Negotiations.

[27] TAIEX - Technical Assistance and Information Exchange instrument of the European Commission.

[28] EEAS - The European External Action Service is the diplomatic service and foreign and defence ministry of the European Union.

[29] The Europe Media Monitor (EMM) is a news gathering engine developed by the JRC for real-time monitoring and analysis of online media, including conventional press and social media, world-wide in 60 languages: http://emm.newsbrief.eu/NewsBrief/clusteredition/en/latest.html

[30] http://eurocodes.jrc.ec.europa.eu/publications.php

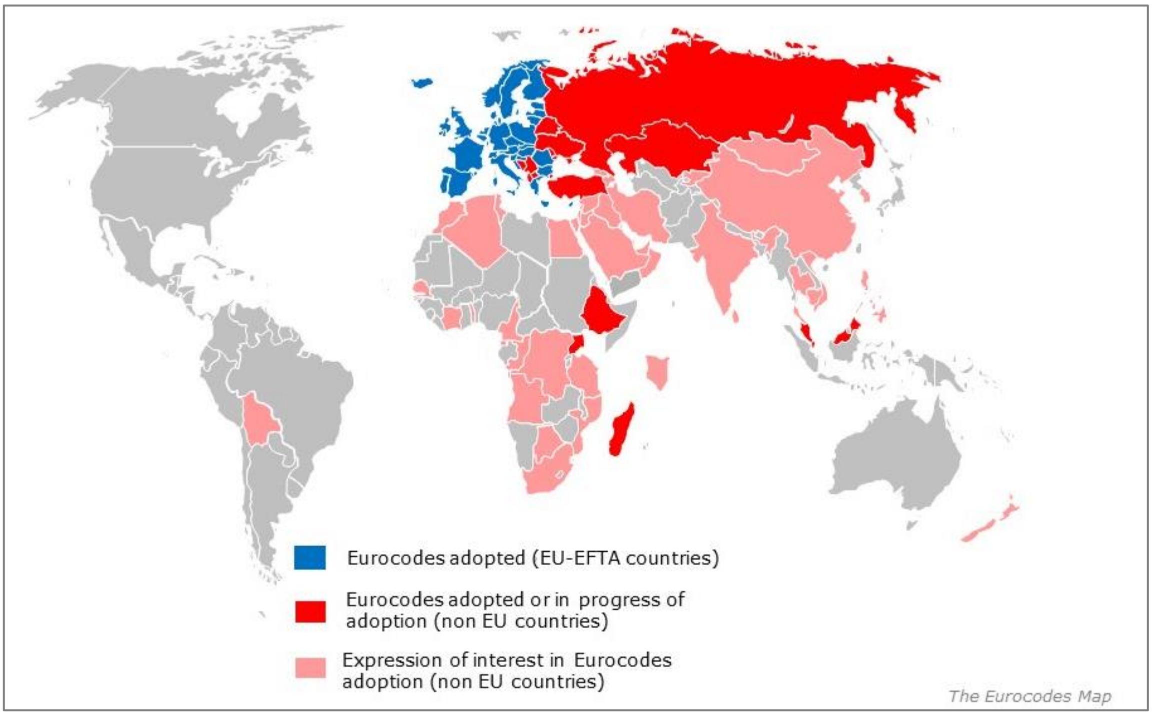

Figure 1.6 The status of worldwide interest in the Eurocodes [Source: https://eurocodes.jrc.ec.europa.eu/]

The European Commission also organises with relevant partners (CEN-CENELEC Management Centre, CEN/TC250, National Standards Bodies and experts) training and promotion events in third countries that have expressed interest and have shown commitment in the Eurocodes adoption. Information and related material from such events, e.g. in the Balkan region, Russia, Georgia, Egypt are available in the European Commission's Eurocodes website.

1.6 Building regulations and standards for long term resilience

In the last decade, low- and middle-income countries have experienced 53% of all disasters globally—but have accounted for 93% of disaster-related fatalities[31]. This disproportionate impact stems in large part from unsafe and unregulated urban development. Though life-saving and relief activities must be the focus in the immediate aftermath of a disaster, the post-disaster period offers a valuable opportunity for reforming building regulatory processes and implementing improved building standards.

Strengthening building regulatory frameworks can save lives and reduce losses in the event of the next potential disaster. It must be recognized that none of these actions will be simple and easy to implement, particularly in the aftermath of a disaster, as they will strongly interact with larger socioeconomic constraints and with more entrenched resource and governance challenges. Building on tangible progress made in engineering

[31] Munich Re, Geo Risks Research, Natcatservice, 2013, in United Nations Integrated Strategy for Disaster Reduction, Global Assessment Report on Disaster Risk Reduction (Geneva: UNISDR, 2015).

and construction technology in the past decades, it is possible to apply lessons learned to deliver safer buildings and save lives[32].

Building Codes and Standards have proven to be a valuable mechanism for capturing experience and effective transfer of scientific and technical knowledge to building practice and community resilience. The European Committee for Standardisation and the International Code Council are valuable sources of state-of-the-art codes and standards, and together with the JRC provide aids for training and technical assistance for building regulation.

Reforming building regulatory processes and implementing improved building standards can help avoid unnecessary costs and losses in the event of the next disaster, while contributing to the achievement a wide range of health, safety and civil rights objectives (i.e. public health, accessibility, cultural heritage protection and energy efficiency).

Eurocodes are a very reliable tool to prevent the creation and reduction of existing risks related to natural and man-made disasters, as they are state-of-the-art standards of practice based on best available knowledge. They can be used in different regulatory systems. The example of implementation of the Eurocodes in the EU shows they are applicable as voluntary national standards and via regulatory frameworks which encompass different amount of Eurocodes parts in the different countries. They also offer each country the possibility to adapt the standards to local conditions and needs. The Nationally Determined Parameters provide opportunity to adapt the implementation of the Eurocodes to specific conditions regarding climate, seismic risk, traditions, and to specific safety requirements.

Eurocodes undergo periodic review and their next generation (expected by 2022) will be updated to further emphasize aspects of disaster risk reduction, such as: (i) assessment, re-use and retrofitting of existing structures; (ii) strengthening of robustness requirements; (iii) adaptation of structural design to climate change; (iv) incorporation of ISO Standards, such as atmospheric icing of structures and actions from waves and currents on coastal structures.

Eurocodes are being introduced in a number of low and middle-income countries as an important element for improving regulatory capacity (e.g. Ethiopia, Kenya, and Georgia) and design of important infrastructure (e.g. India). The use of the Eurocodes in design of bridges and important buildings increases the resilience of urban areas. In the same time, they are applicable to simple structures: the Eurocodes provide provisions for simplified methods of analysis and design, Categories of Use for the definition of actions, Importance Classes for seismic design of buildings and rules for the seismic design of 'simple masonry buildings'.

An example for the use of the Eurocodes for design of important infrastructure in third countries is the Anji Khad bridge project in India (see Figure 1.7). The India's first mega cable-stayed railway bridge in Jammu-Kashmir region will have a 290 m long main span suspended only by one side to a 200 m high tower, its top being at 380 m over the Anji river. The design was based on Indian Codes as far as it concerns the actions while the Eurocodes have been used for the structural analysis and check.

The Building Regulation for Resilience program, an integral part of the World Bank's broader Resilient Cities agenda, seeks to develop a new stream of activities to increase regulatory capacity and in turn promote a healthier, safer, and less risky built environment in low- and middle-income countries. By leveraging good practice in building

[32] Proceedings and knowledge report of World Reconstruction Conference 3 "Promoting resilience through post-crisis recovery", June 6-8 2017, Brussels, https://www.gfdrr.org/sites/default/files/publication/WRC3%20Proceedings%20and%20Knowledge%20Report%20FINAL.pdf

regulation as part of a strategy to reduce both chronic risk and disaster risk, it will set developing countries on the path to effective reform and long-term resilience. Consistent with Priorities 2 and 3 of the Sendai Framework for Disaster Risk Reduction (2015-2030), which aim to better understand disaster risks and strengthen governance to manage them, the program will respond to and reinforce the growing international consensus on the importance of building and land use regulation. The program will also form an integral part of the World Bank's broader agenda for resilient cities. The primary priorities of the program are (i) to stop the expansion of disaster and chronic risk in the siting and construction of new settlements and (ii) to reduce disaster risk in vulnerable existing settlements. The program is a global partnership of governments, international development institutions, and key public, private and non-governmental actors in the building sector.

Figure 1.7 Anji Khad bridge project, Kashmir, India [© Italferr]

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CHAPTER 2

TOWARDS THE SECOND GENERATION OF THE EUROCODES

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2 Towards the second generation of the Eurocodes

2.1 Introduction

The structural Eurocodes enable the design of buildings and civil engineering works and comprise 10 Standards in 58 parts. When they were published, prior to 2007, the first generation of Eurocodes were the most comprehensive and technically advanced suite of standards for structural and geotechnical design in the world.

In May 2010, the European Commission initiated, in cooperation with CEN (European Committee for Standardization), the process of further evolution of the Eurocode system, incorporating both new and revised Eurocodes, and leading to the publication of the "second generation" of Eurocodes. The work programme, set up by CEN as a reply to the EC Mandate M/515, was then focused on ensuring the standards remain fully up to date through embracing new methods, new materials, and new regulatory and market requirements. Furthermore, it focused on further harmonisation and a major effort to improve the ease of use of the suite of standards for practical users.

The present contribution addresses the key aspects of the European Commission's Mandate M/515 and related work being developed by experts towards the second generation of the Eurocodes, highlighting the benefits in terms of ease-of-use and increased harmonization through the reduction of Nationally Determined Parameters (NDPs).

2.2 Eurocodes' history in brief

It has been said that the structural Eurocodes, which nowadays are the common European language for structural engineers, were, in the beginning, like a "*dream*". The dream to have common technical rules for engineers to facilitate the international exchange of design services within the European Community, and, possibly, beyond its boundaries. The "*dream*" is adequately summarised by the main objectives of these standards as set out by the Commission of the European Community:

- "The Eurocodes to establish a set of common technical rules for the design of buildings and civil engineering works which will ultimately replace the differing rules in the various Member States".
- "Elimination of technical obstacles to trade and the harmonisation of technical specifications".

Towards these objectives a huge effort was spent since the early 1970s, when the Commission of the European Community agreed on an action programme in the field of construction, based on Article 95 of the Treaty of Rome and established the "Steering Committee" containing representatives of EU member states, in charge of the preparatory works for the elaboration of the European common set of rules in the main fields of civil engineering works.

The Eurocodes' story is thus a very long one (see Figure 2.1) and dates back to the period 1976-1990, when a first set of draft standards were developed. These standards (Figure 2.2), were titled "Common Unified Rules" and were prepared both as general set of rules (the current EN 1990 "Basis of Design") and for the specific materials, such as reinforced concrete, steel, timber (the current EN 1992, EN 1993, EN 1995 etc.).

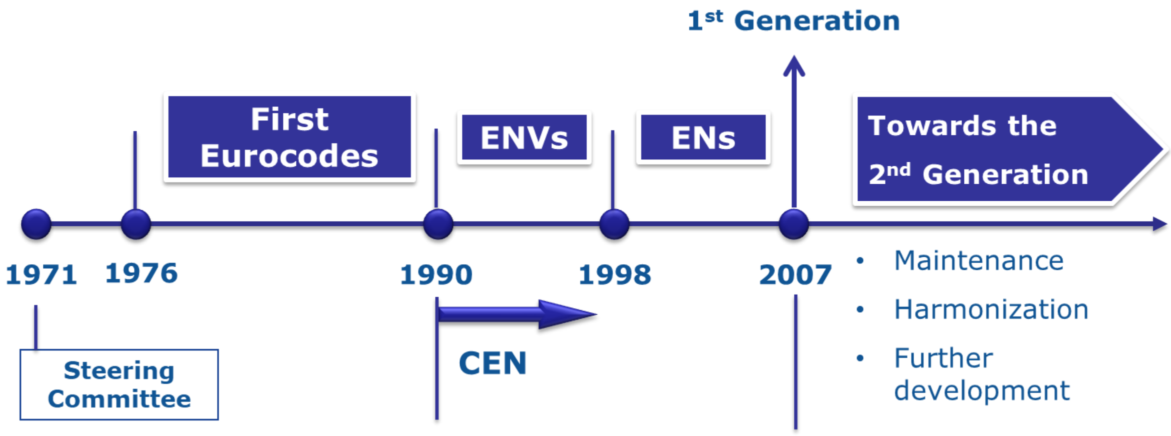

Figure 2.1 Eurocodes development timeline

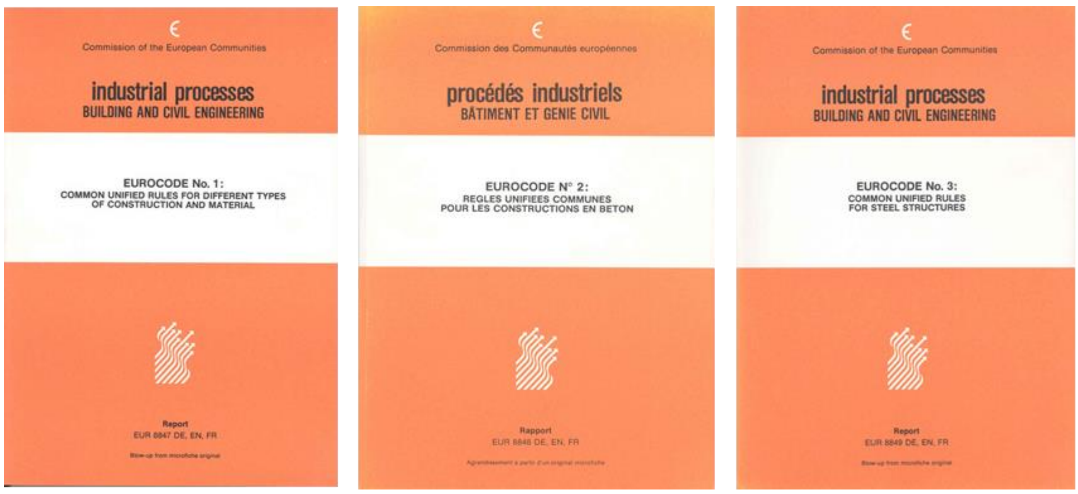

Figure 2.2 The first Eurocodes drafts

In 1990, the European Community, considering the need of a continuous evolution of the drafts, their extended coverage in the different fields of Civil Engineering and the high level of the technical discussion arising around these documents, transferred to CEN the leading role and the responsibility of the preparation and publication of the Eurocodes, thus providing the Eurocodes with a future status of European EN standards.

In the last decade of the last century, CEN published a complete set of European pre-standards, the so called "*ENVs*". These standards were mainly intended to serve as a basis for discussion among experts from different countries in the EU and EFTA (European Free Trade Association) countries and to stimulate pre-normative research on common background, the results of which would have been eventually incorporated in the future EN standards, for the implementation and use in member states. These pre-standards included the so called "*boxed values*", which allowed CEN member states to include the parameters to be specified at national level, such as partial factors for actions and material resistances, as well as country specific data, such as maps for climatic actions (wind, snow, temperature). Boxed values were the ancestors of the Nationally Determined Parameters (NDPs), which nowadays are included in the Eurocodes.

After almost ten years of preliminary implementation of the ENVs and having matured a relevant set of pre-normative research results, in 1998 CEN started the conversion phase of the ENVs into European Standards (ENs). A huge collaborative work took place and the publication of Eurocodes, which started in 2002 was completed in 2007. The first generation of the Eurocodes was in place, ready to be implemented in CEN member states, where the conflicting national standards were to be withdrawn by March 2010. The "*dream*" was becoming reality.

The suite of the "1st generation" of the Eurocodes includes 10 Eurocodes subdivided in 58 parts, as indicated inTable 2.1.

Table 2.1 The Eurocodes suite

EN Number	The Structural Eurocodes (58 parts)	N° of Parts
EN 1990	Eurocode: Basis of structural design	1
EN 1991	Eurocode 1: Actions on structures	10
EN 1992	Eurocode 2: Design of concrete structures	4
EN 1993	Eurocode 3: Design of steel structures	20
EN 1994	Eurocode 4: Design of composite steel and concrete structures	3
EN 1995	Eurocode 5: Design of timber structures	3
EN 1996	Eurocode 6: Design of masonry structures	5
EN 1997	Eurocode 7: Geotechnical design	3
EN 1998	Eurocode 8: Design of structures for earthquake resistance	6
EN 1999	Eurocode 9: Design of aluminium structures	3

2.3 The first generation of the Eurocodes

The publication of the first generation of Eurocodes has been a tremendous achievement; at the time of publication these standards were defined as "*the most comprehensive and technically advanced suite of standards for structural and geotechnical design in the world*".

The Eurocodes, result from over 30 years collaborative work by experts, National Standards Bodies and regulators across Europe and are a complete set of design standards that cover all principal construction materials, all major fields of structural engineering and a wide range of types of structures. They are conceived as a system, offering structural and geotechnical design rules for buildings and civil engineering works, where different parts are interrelated to each other as diagrammatically shown in Figure 2.3. Furthermore, the Eurocodes are intrinsically flexible, offering the possibility for each country to choose the levels of safety and specific data or methods through the Nationally Determined Parameters (~1500 in the whole suite).

Eurocodes are undoubtedly a major tool for the successful removal of trade barriers for construction products and services and contribute to the safety and protection of the people in the built environment, on the basis of the best possible scientific advice. Furthermore, the Eurocodes are a common basis for technical and scientific collaboration among researchers in EU and EFTA member states.

Some figures help to better clarify the relevance of this achievement (*CEN/TC250 Business Plan ed. 2017*):

- 34 CEN countries (EU + EFTA);
- 1800 € billion – annual value of the European construction market (~6-7% of the European GDP);
- 75 billion € annual value of the EU market for design services;
- 500 000 engineers using the Eurocodes in their day-to-day activities.

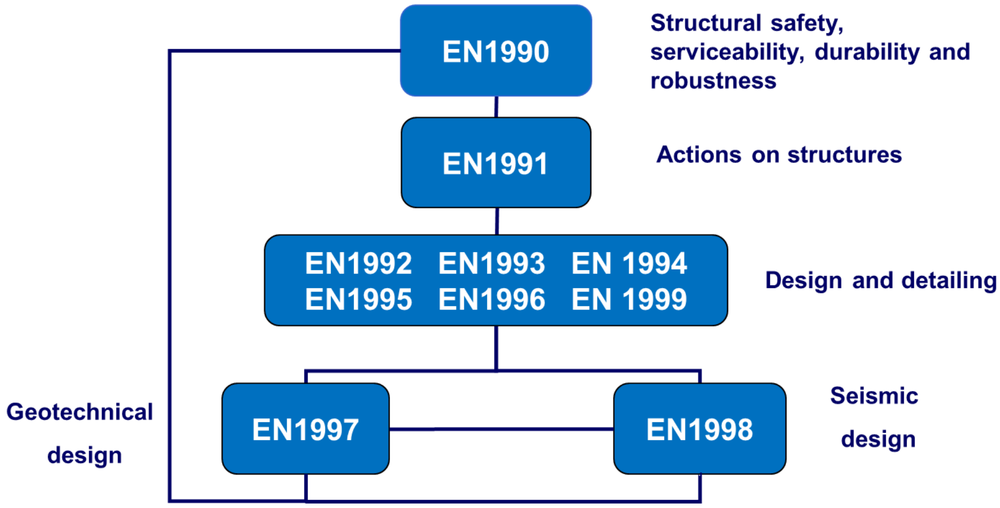

Figure 2.3 Links among the Eurocodes

From a legal point of view, Eurocodes are standards of practice, intended to serve as reference documents to be recognised by authorities of the Member States for the following purposes:

- As a means for enabling building and civil engineering works to comply with the Essential Requirements 1, 2 and 4 of the Construction Products Directive (89/106/EEC), mechanical resistance and stability, safety in case of fire and safety in use; now replaced by the Construction Products Regulation (EU/305/2011) with Basic Requirements for Construction Works 1, 2 and 4[1].
- As a basis for specifying public construction and related engineering service contracts; Works Directive (EU Directive 2014/24 contracts for public works, public supply and public service), which covers procurement by public authorities of civil engineering and building works and the Services Directive (EU Directive 2006/123 on services in the Internal Market), which covers public procurement of services. In addition, EU Directive 2014/23 concerns the award of concession contracts.
- As a framework for drawing up harmonised technical specifications for construction products.

Application of the Eurocodes in the EU Member States supports Directive 2006/123/EC of the European Parliament and of the Council of 12 December 2006 on services in the internal market ("Services Directive"). Disparities in design/calculation methods of the national building regulations constitute impediments to the free circulation of engineering and architectural services within the Community. The implementation is intended to facilitate the provision of services in the field of construction engineering by creating conditions for a harmonised system of general rules.

Since 2007, CEN member countries initiated the preparation of the national annexes, making the suite fully operational in each country. Outstanding structures were designed according to the Eurocodes, such as, just to give some examples, the Millau viaduct (Norman Foster) or the railway station in Liege (Santiago Calatrava), as show on the left and right, respectively, in Figure 2.4

[1] The Construction Products Regulation has also introduced Basic Requirement 7 on the sustainable use of natural resources

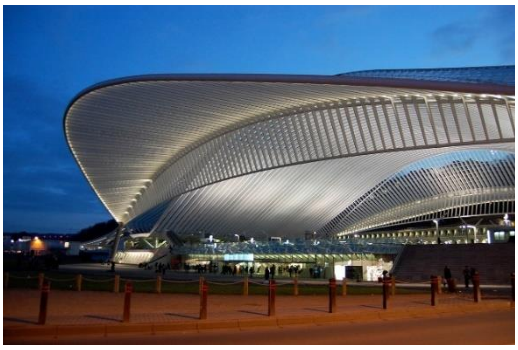

Figure 2.4 Examples of outstanding structures designed according to the Eurocodes
[Source: (a) left: http://internal.schreder.com/en-au/projects/millau-viaduct © Schréder Group, (b) right: https://en.wikipedia.org/wiki/Li%C3%A8ge-Guillemins_railway_station]

Not only for such complex structures, the Eurocodes need to be suitable for "simple" structures as well, resulting easily applicable for day-to-day designs. This aspect deserves specific consideration being a great challenge for the ease of use of standards: "… *suitable and clear for all common design cases without demanding disproportionate levels of effort to apply them*" (CEN/TC250 Position Paper on enhancing the ease of use of the Eurocodes).

Over the last decade, the Eurocodes have successfully passed the test of practical implementation and have become the primary standards for structural and geotechnical design across Europe and in many other countries around the world, as seen in Figure 2.5.

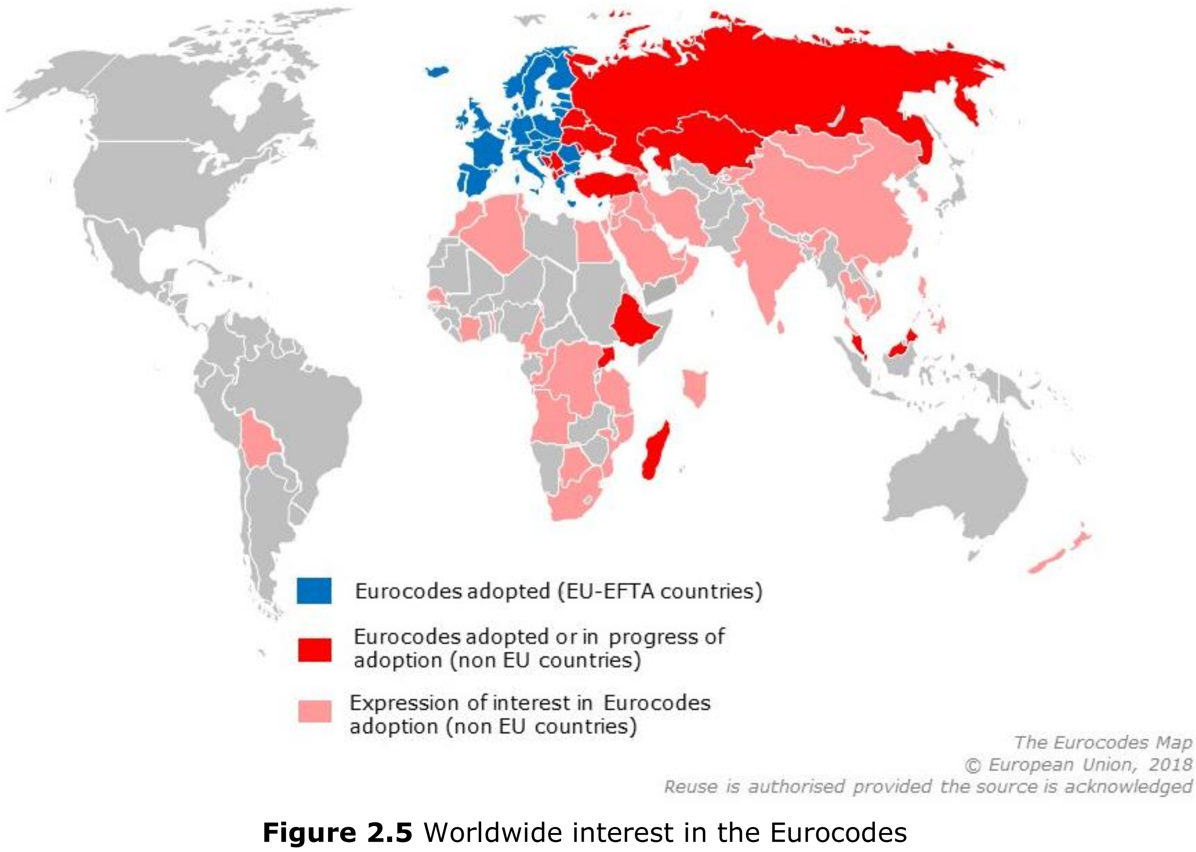

Figure 2.5 Worldwide interest in the Eurocodes
[Source: https://eurocodes.jrc.ec.europa.eu/]

Long-term confidence in these standards requires them to evolve and remain up-to-date in appropriate manner, as it was recognised by the Commission Recommendation (2003/887/EC), on the implementation and use of the Eurocodes for construction works and structural construction products, where the EU Member States are invited to adopt the Eurocodes as a suitable tool for designing construction works and the clear needs for "*continuous efforts to maintain the Eurocodes at the forefront of engineering knowledge and developments in structural design […] including new materials, products and construction methods*" are set out.

The areas to look at for this maintenance were identified also thanks to the feedback from users, collected in the years of the implementation of the "first generation", through the Systematic Review process, set up by CEN as a means to collect inputs for further evolution of the standards and to identify topics on which major attention is required.

In these last years, a need also emerged for the standardisation of design criteria for new materials, new types of structures as well as for the assessment and retrofitting of existing structures, which is more and more the main field of activity for engineers in many countries in Europe.

Furthermore, the extensive use of the Eurocode suite across different countries in Europe, puts in evidence the need for further harmonization and that enhanced ease of use for day-to-day applications would be beneficial to the main objectives set out by the Commission.

These are, in brief, the motivations for the evolution of the Eurocodes suite towards its "second generation".

2.4 Towards the second generation of the Eurocodes

In May 2010, thus immediately after the date of withdrawal of the existing conflicting national standards, the European Commission, Enterprise and Industry Directorate-General, sent the Programming Mandate M/466 EN to CEN concerning the Structural Eurocodes. The purpose of this mandate was to initiate the process of further evolution of the Eurocode system, incorporating both new and revised Eurocodes, and leading to the publication of the so called "second generation" of Eurocodes.

CEN replied to the programming mandate in June 2011, with a general work programme, that was positively received by the Commission.

In December 2012, the European Commission sent a further Mandate M/515 EN, inviting CEN to develop a detailed standardisation work programme, using the reply to mandate M/466 as a basis. The preparation of the reply involved more than 1000 experts from across Europe and the document was unanimously approved by TC250 in May 2013 (CEN-TC250, 2013 N0993 Specific Mandate Response M515).

The over-arching objective for the work programme set out in the response is to address the challenges to reflect the state of the art and the needs of the internal market. With the European market for design services in the construction sector being approximately 75 billion €, even very modest efficiency savings will yield very substantial monetary benefits for public and private sector clients.

The proposed work programme leads to additional structural Eurocodes and substantial additions to the existing ones. As illustrated in the following, the new suite of Eurocodes will introduce requirements for the assessment, re-use and retrofitting of existing structures, guidance for the design of glass, Fiber Reinforced Polymers (FRP) and membrane structures. Requirements for robustness will be strengthened and the practical use of Eurocodes for day-to-day calculations will be improved.

The development of the second generation of EN Structural Eurocodes is a complex and challenging task and some driving principles have to be considered when planning the revision phase.

First of all, a smooth transition from the first to the second generation has to be safeguarded, therefore the second generation of Eurocodes is intended to be an "*evolution*" and not a "*revolution*" of the existing standards. In addition, the high level of interdependency between the many Eurocodes' parts calls for a careful planning of the work programme, phasing the activities in packages to promote technical consistency of the different parts, which is a key aspect when considering the ease of use. A clear understanding of priorities is also essential, setting out realistic objectives in the context of the available timescales and budgets.

The CEN/TC250 reply to the Mandate M/515 was approved by the European Commission and the evolution work started at the beginning of 2015 with the first of the four overlapping phases, in which the entire work programme was subdivided (Figure 2.6, Figure 2.7). Phase 1 includes parts of the work programme upon which other activities are primarily dependent for reasons of overall coordination, technical scope or because they are essential for achieving the target dates for delivery of the next generation of Eurocodes. For this reason, the head code EN 1990, is included in phase 1 since other Eurocode parts will need to be drafted consistently with the updated provisions in the new EN 1990 "Basis of Design".

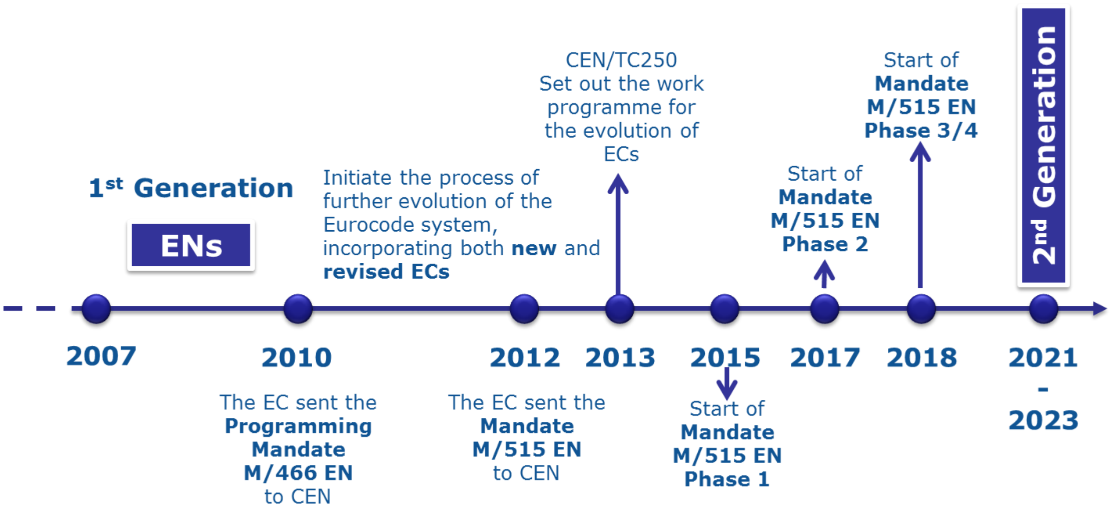

Figure 2.6 Timeline towards the "second generation" of the Eurocodes

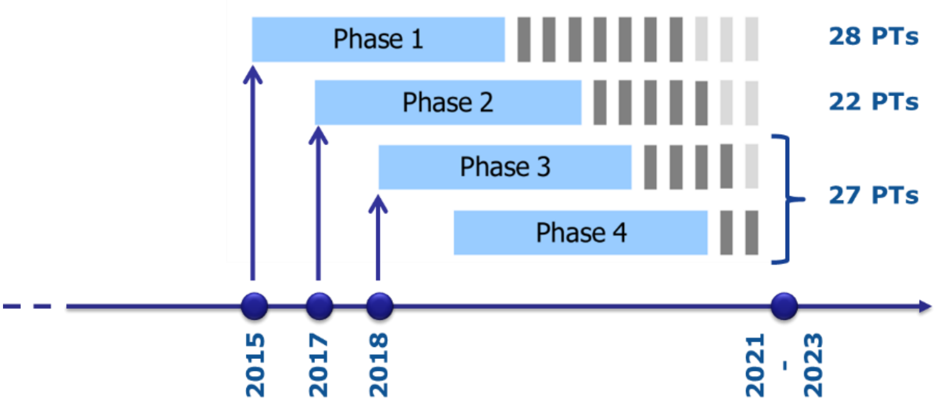

Figure 2.7 The four overlapping phases for the evolution of the Eurocodes

Further to the plenary TC250, responsible of the coordination of the entire work programme, the activity involves the whole TC's sub-structure (Figure 2.8) made up by 11 Sub-Committees and their subordinate groups (Working Groups and Task Groups), 5 TC250 Working Groups (WGs), 2 Horizontal Groups (HG) and 77 Project Teams (PTs), globally involving more than 1000 experts acting at international level and 34 mirror committees in the CEN Member States.

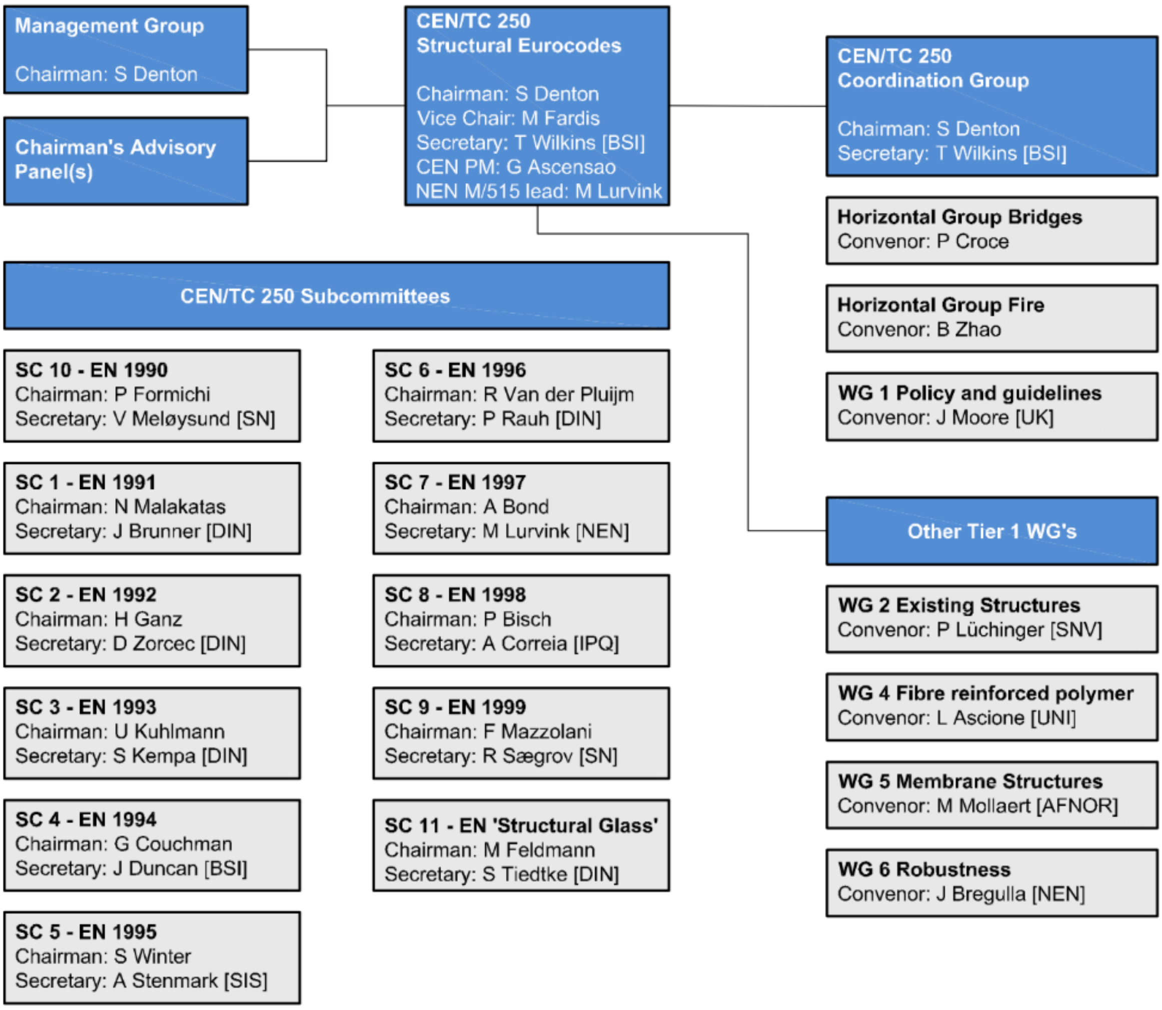

Figure 2.8 CEN/TC250 Organogram [© CEN]

The evolution activity is a fully transparent process. Project Teams of 5 to 6 experts, selected with an open call ("Call for Tenders - Grant Agreement CEN/2014-02 Volume 1 - Instructions to tenderers"; CEN, 2015) and contracted by NEN, the Dutch standardization institute, are working in strict co-operation with their parent bodies (SCs, WG, etc.) presenting and discussing their drafts in subsequent steps. As an example, in the work plan of the PTs in phase 1, three drafts were presented by the PTs to their parent bodies and for each draft national delegations commented and interacted with the PT. After the completion of the final PT documents a further informal enquiry was held, giving a three months' time to submit comments to the PT (Figure 2.9).

The driving concept of the above process is to guarantee an early interaction with national standard bodies ahead of the formal vote, to address the main concerns expressed at national level, the PT being active and able to modify/adapt the drafts.

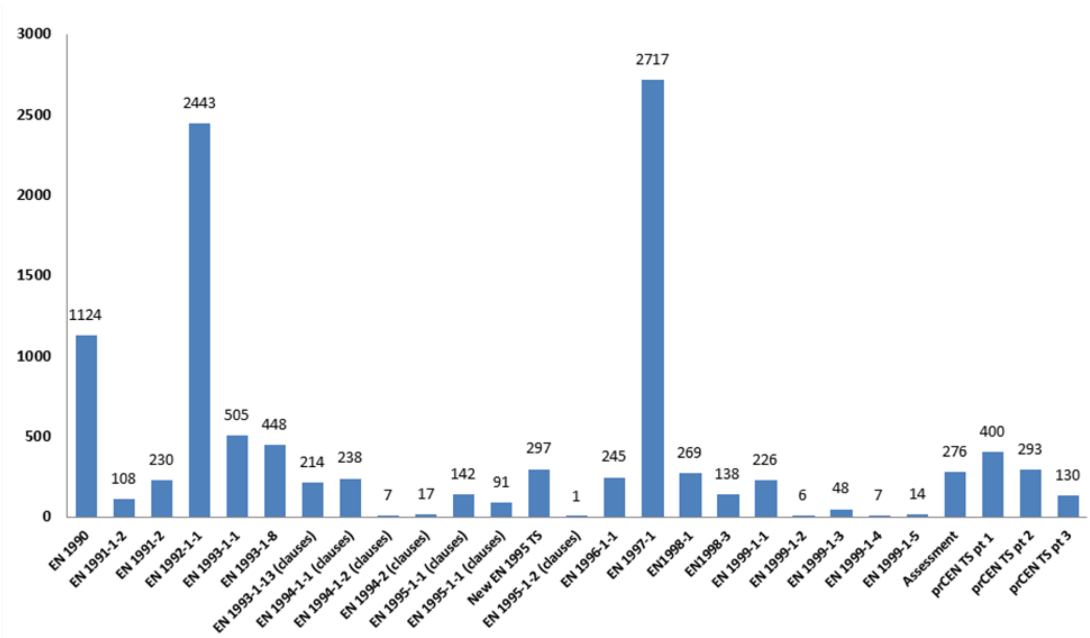

Figure 2.9 Phase 1, distribution of informal enquiry comments
[Source: TC250_N1969_Chairman_s_presentation_at_CENTC_250_meeting]

2.4.1 Key objectives

As declared in the CEN/TC250 reply to the mandate M/515, the primary objectives of the evolution of the Eurocodes are to "embrace new methods, new materials, new regulatory requirements and new societal needs, fostering more economic and sustainable design and construction". Furthermore, a great attention is devoted to the enhancement of the ease of use of the suite for practical users, at the same time not preventing innovation and sustaining the market developments, also by means of enhanced harmonization reducing the number of Nationally Determined Parameters.

One of the main requests from the market is undoubtedly the provision of rules for the assessment and retrofitting of existing structures. In the recent years, design services in this field are growing more and more in the European market and an update of the Eurocodes suite to cover existing structures is necessary. This is not only valid in seismic regions, where the existing EN 1998-3 (Eurocode 8: Design of structures for earthquake resistance – Part 3: Assessment and retrofitting of buildings) already gives guidance, but also in other regions, where sustainability or preservation requirements are leading more and more to the re-use of the built environment, rather than to new constructions, widely recognising the importance of extending the life of existing assets thereby delivering environmental, economic and socio-political benefits (Figure 2.10).

To address this request, the Working Group 2 of TC250 and its Project Team, are preparing a new Eurocode on the "Assessment and Retrofitting of Existing Structures". The process is in steps and includes the publication of:

- a JRC Report, as a first document publicly available to collect available information, draft the intended set of provisions and, mainly to serve as a basis to stimulate the discussion at the international level;
- the CEN Technical Specification (TS), which is a normative document developed in anticipation of future harmonization, or for providing specifications in experimental circumstances and/or evolving technologies, such as the ENVs were in the '90s;

- the full EN standard.

The JRC report (JRC, 2015) is available[2] and the CEN TS is under preparation on the basis of the work developed by the Project Team under the WG2 of TC250.

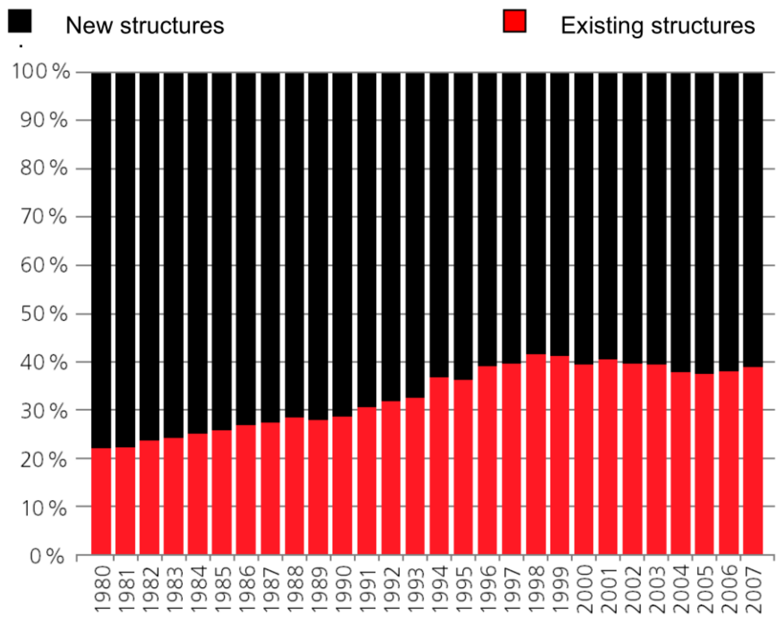

Figure 2.10 Increasing rate of retrofitting existing building and engineering works (JRC, 2015)

Another key objective in the evolution of the Eurocodes is the strengthening of requirements for structural robustness. The aim is to develop a clear definition of robustness and proportional measures in the Eurocodes, including methodology and practical measures with respect to foreseen (normal and accidental) and unforeseen (accidental) events in relation to the consequence class of the structure. As it is easily understood this is one of the most challenging tasks in the evolution of the Eurocodes, since it brings a number of relevant implications in terms of responsibilities for designers, contractors and clients, as the protection against the unforeseen events is concerned. The effort is to provide rules as clear and as general as possible to avoid additional and/or empirical rules for particular structure or structural-element types, all to the extent that is reasonably practical.

It is expected that both EN 1990 "Basis of structural design" and EN 1991-1-7 "Accidental actions" will be affected by the general provisions on robustness to be developed under phase 1 of the mandate M/515 and all the so-called "material Eurocodes" (EN 1992 to EN 1996 and EN 1999), will include (phase 2 of the mandate) new and modified rules addressing the practical design criteria to enhance robustness for different construction materials.

Due to the horizontal nature of the discussion and the complexity of the subject, the Working Group 6 of TC250 envisaged the need to develop a JRC Report to collect the most up-to-date background material in this field and to illustrate the design principles, as well as to facilitate the exchange of view across TC250. The preparation of this report is currently underway.

[2] https://eurocodes.jrc.ec.europa.eu/showpublication.php?id=535

Looking at the new regulatory need to embrace new materials, the mandate M/515 includes the activities for the publication of three new Eurocodes, to deal with:

- o Structural design of glass components,
- o FRP structures,
- o Membrane structures.

As for the new Eurocode part on the assessment and retrofitting of existing structures, the process being followed foresees the three steps: JRC report, CEN TS and finally the new EN standard.

In modern architecture and civil engineering structural glass is getting more and more importance because of its transparency and lightening functions. This is shown by the variety and huge number of recent structural applications, ranging from simple glass barriers to glass elements with important primary functions like floors, columns or shear panels. A good example of the evolution of the technology in this field is provided by the "glass cube" erected in the 5th avenue in New York in front of the Apple store. Two geometrically identical glass structures were built in 2006 and 2011 respectively: the first one including 90 glass panels and the second one with only 15 panels (see Figure 2.11).

Figure 2.11 Evolution of glass structures
[Source: (a) left: https://www.geek.com/apple/apple-begins-6-7m-renovations-of-fifth-ave-store-1392143/, (b) right: https://siecledigital.fr/2013/11/13/apple-stores/]

The TC250 work is being developed within its Sub-Committee 11, the JRC report was published in 2014 (JRC, 2014) and the CEN/TS is currently being drafted.

Another "new" material in standardization for Civil Engineering applications is FRP. Over the last twenty years innovative applications confirmed the relevance of composite FRP structures, with a steadily increasing market volume. Just to give an idea in 5 years (from 2011 to 2016) they were produced 1 million tons of GFRP (glass fibre reinforced polymer), and 35% of these were used in the civil construction sector. FRP structures are highly competitive where specific needs are driving the design, such as the requirement for speed of assembly on site or the necessity for an enhanced durability, which in turn reduces overall and maintenance costs. Within this context, the use of FRP profiles, shell structures and sandwich panels is particularly advantageous for applications in Civil Engineering and the availability of a standardization document is therefore needed to give answers to the market's requirements. Figure 2.12 presents a view of the FRP movable deck of the Nelson Mandela Bridge in Alkmaar.

Figure 2.12 Nelson Mandela Bridge in Alkmaar (NL) FRP movable deck
[Source: https://www.royalhaskoningdhv.com]

Another field where innovation in the market calls for a standardization document is membrane structures. The use of such structures dates back to decades ago, when they were mainly used as highly curved roofs, being able to economically and attractively span large distances e.g. for sport halls. Nowadays their use ranges from small scale canopies to facades (dynamic solar shading, solar harvesting systems etc.) and lightweight roofing, inflated and air supported membranes (see example of use in **Figure 2.13**). Standards for the design of membrane structures exist in only few European countries, despite a considerable amount of scientific knowledge about their structural behaviour. The need for a common approach to the design of these structures, to reach harmonized safety levels is the main motivation for the development of the new Eurocode.

Figure 2.13 Cargolifter airship Hangar
[Source: http://atlasofplaces.com/CargoLifter-SIAT-GmbH]

As for glass structures, two JRC reports have been published in 2016, respectively on the design of FRP (Fibre Reinforced Polymers or Plastics) and membrane structures (JRC, 2016a; JRC, 2016b). The responsible Working Groups in TC250 are WG4 and WG5.

Finally, as far as new technical coverage of the Eurocodes is concerned, the second generation of Eurocodes will enlarge the coverage of EN 1991 "Actions on Structures" to include guidance for the determination of actions induced by Atmospheric Icing and Waves and Currents. This activity will be carried out by two Project Teams under Sub-Committee 1 of CEN/TC250, converting two corresponding ISO standards (ISO 12494:2017 "Atmospheric icing of structures" and ISO 21650:2007 "Actions from waves and currents on coastal structures", respectively) to a format fully compatible with the Eurocodes suite.

Further to the technical enlargement of the coverage of the second generation of Eurocodes briefly illustrated above, one of the overarching driving principles in the evolution work is the improved ease of use of the standards.

Immediately after the publication of the first generation of the Eurocodes in 2007, the discussion about the "*simplification*" of the Eurocodes took place. The standards were being used by practitioners and conflicting national standards were to be withdrawn within 2010 by national standard bodies. The Eurocodes were felt to be complex for day-to-day applications and the request for simplification was one of the feedbacks from practical users.

To better understand this request, we have to consider that the Eurocodes are academically based, and a strong scientific background is needed for designers, also to fully understand and correctly apply the provided methods, that could be different from the consolidated national practices. As first attempt to give answers to the request for simplification, some institutions in Europe, including some Standard Bodies, published shortened versions of the Eurocodes, including only those parts which were considered useful for the day-to-day applications, for "simple" buildings. Despite the apparently good aim, this exercise was not really successful, since the "simplified" Eurocodes were not helpful as soon as the "simple" building deviated from the assumed field of application of the "simplified" set of rules.

The discussion that followed in TC250 about the simplification of the Eurocodes, showed that this issue is one of the most complicated ones to be addressed. What is a "simple" building or bridge is impossible to be defined across different CEN member states. Furthermore, the Eurocodes need to cater for complexity and, at the same time, for less demanding applications and the "simplification" of rules should not in any case lead to get "simplistic rules".

This is in brief the context of the discussion within TC250, when the following resolution (n. 280) was unanimously adopted at a meeting in Helsinki in June 2010.

Subject: CEN/TC 250 – simplification of Eurocodes

CEN/TC 250 acknowledges the challenge established in the Programming Mandate M/466 addressed to CEN in the field of the Structural Eurocodes to examine the potential for simplification of rules in the further development of the Eurocodes.

CEN/TC 250 agrees to work towards achieving such simplification in the further development of the Eurocodes to support the ease of their use by designers through:

(i) improving the clarity;

(ii) simplifying routes through the Eurocodes;

(iii) limiting, where possible, the inclusion of alternative application rules;

(iv) avoiding or removing rules of little practical use in design.

CEN/TC 250 agrees that such simplification should be limited to the extent that it is technically justified and should seek to avoid additional and/or empirical rules for particular structure or structural-element types.

The resolution introduced a significant change: from "simplification" to "ease of use", which better explains the scope of the engagement of TC250 towards the second generation of Eurocodes.

In 2013 a TC250 Chairman Advisory Panel (CAP) was established to develop recommendations for the approach to be taken to enhance the ease of use of the Eurocodes and in 2015 a Position Paper on this subject was unanimously approved by national delegations to TC250 (CEN/TC250, 2015).

In that document it is affirmed that "respecting the achievements of the past, our vision for the second generation of Structural Eurocodes is to create a more user-orientated suite of design standards that are recognised as the most trusted and preferred in the world". To this aim five pillars are identified as shown in Figure 2.14.

Figure 2.14 The 5 pillars to enhance the Ease of Use of the Eurocodes

The first pillar is about the statements of intent to meet user's needs, which will be identified as primary objectives in the effort to enhance the ease of use. In the discussion within the CAP it was recognised that it would have not been possible to fulfil all the users' aspirations simultaneously and a primary target audience was identified to take precedence in case of conflicting needs of other audiences. The primary target audience is "Practitioners – Competent Engineers", identified as "*Competent civil, structural and geotechnical engineers, typically qualified professionals able to work independently in relevant fields*", for whom the following TC250 statement of intent is agreed "*We will aim to produce Standards that are suitable and clear for all common design cases without demanding disproportionate levels of effort to apply them*".

As shown in the following Figure 2.15, other categories of users include expert specialists, software developers, educators, product manufacturers, clients and many others and for each of these a specific statement of intent is expressed.

To fulfil the intents and to guide the drafting towards more user-orientated standards, a number of governing principles have been agreed, distinguishing primary and secondary ones. These principles, listed in Figure 2.16, reflect the best practice in the development of standards and are consistent with CEN's internal regulations.

Another pillar is to provide examples to the Sub-Committees and Project Teams to enhance ease of use, to illustrate the application of the governing principles through relevant examples and to promote shared understanding and convergence of approach (e.g. through a better organisation of contents, better harmonisation, etc.).

One good example is offered by the new architecture of EN 1990, as illustrated in Figure 2.17.

CATEGORIES OF EUROCODES' USERS	CEN/TC 250 STATEMENTS OF INTENT
Practitioners – Competent engineers [Primary target audience]	We will aim to produce Standards that are suitable and clear for all common design cases without demanding disproportionate levels of effort to apply them
Practioners – Graduates	We will aim to produce Eurocodes that can be used by Graduates where necessary supplemented by suitable guidance documents and textbooks and under the supervision of an experienced practitioner when appropriate
Expert specialists	We will aim not to restrict innovation by providing freedom to experts to apply their specialist knowledge and expertise
Product Manufacturers	Working with other CEN/TCs we will aim to eliminate incompatibilities or ambiguities between the Eurocodes and Product Standards
Software developers	We will aim to provide unambiguous and complete design procedures. Accompanying formulae will be provided for charts and tables where possible
Educators	We will aim to use consistent underlying technical principles irrespective of the intended use of a structure (e.g. bridge, building, etc.) and that facilitate the linkage between physical behaviour and design rules
National regulator	We will endeavour to produce standards that can be referenced or quoted by National Regulations
Private sectors businesses	We will continue to promote technical harmonization across European markets in order to reduce barriers to trade
Clients	We will produce Eurocodes that enable the design of safe, serviceable, robust and durable structures, aiming to promoting cost effectiveness throughout their whole life cycle, including design, construction and maintenance
Other CEN/TCs	We will engage proactively to promote effective collaboration with those other CEN/TCs that have shared interests

Figure 2.15 Statements of intent to meet Eurocodes users' needs
[Source: CEN/TC 250, 2015 - N 1239 – Position paper on enhancing ease of use of the Structural Eurocodes]

General principles (primary)	
1	Improving clarity and understandability of technical provisions of the Eurocodes
2	Improving accessibility to technical provisions and ease of navigation between them
3	Improving consistency within and between the Eurocodes
4	Including state-of the-art material the use of which is based on commonly accepted results of research and has been validated through sufficient practical experience
5	Considering the second generation of the Eurocodes as an "evolution" avoiding fundamental changes to the approach to design and to the structure of the Eurocodes unless adequately justified
Specific principles (secondary)	
6	Providing clear guidance for all common design cases encountered by typical competent practitioners in the relevant field
7	Omitting or providing only general and basic technical provisions for special cases that will be very rarely encountered by typical competent practitioners in the relevant field
8	Not inhibiting the freedom of experts to work from first principles and providing adequate freedom for innovation
9	Limiting the inclusion of alternative application rules
10	Including simplified methods only where they are of general application, address commonly encountered situations, are technically justified and give more conservative results than the rigorous methods they are intended to simplify
11	Improving consistency with product standards and standards for execution
12	Providing technical provisions that are not excessive sensitive to execution tolerances beyond what can be practically achieved on site

Figure 2.16 Principles and related priorities for the 2nd Generation of the Eurocodes

The rearrangement of the main text and of the normative and informative annexes is intended to facilitate the use of the standard: the main text is the proper normative part and includes all the detailed information needed for the complete understanding and correct implementation of the provisions; the normative Annex A includes the operational guidance, which is easily understood once studied the main text and is intended to serve as a day-to-day tool for the practical applications giving, for example, the combination rules and the partial factors for the design of buildings, bridges etc.; the informative annexes following Annex A are given to provide detailed information on specialist aspects, such as the guidance for the reliability analysis or the design assisted by testing. This clear distinction in the presentation of the different parts of EN1990 will contribute to the correct interpretation of the rules and, at the same time, will make the document more user-oriented for a quick navigation though its contents.

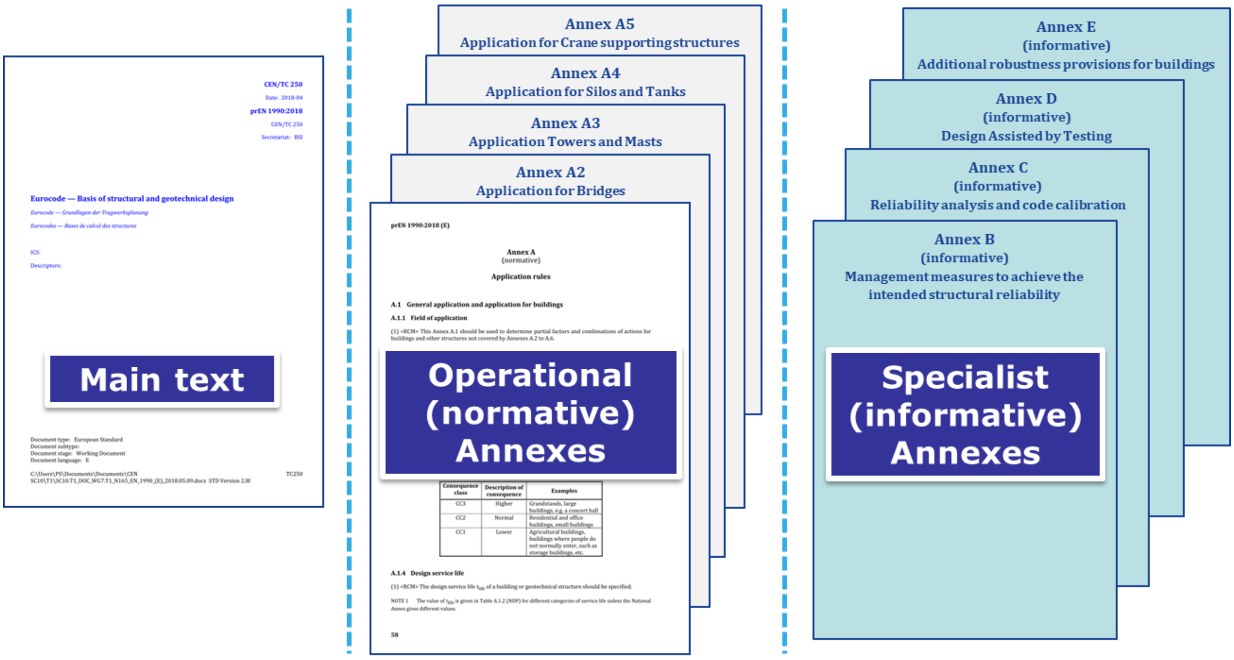

Figure 2.17 EN 1990's architecture

As far as the last two pillars are concerned (i.e. strategic performance measures and management, governance and support), TC250 is acting through a Technical Reviewer, who is in charge of a detailed check of all the parts to ensure consistency across them, understandability, easy navigation etc. Further to this, the Management Group of TC250, is responsible for monitoring the overall application of the agreed guidelines in the Position Paper N1239.

2.4.2 Increased harmonisation

The increased harmonisation of the Eurocodes, by means of a reduced number of Nationally Determined Parameters (NDPs) is an agreed objective of CEN/TC250 and a specific requirement of the European Commission.

One of the key features of the Eurocodes is their flexibility allowed by the implementation of national choices: the "European Commission recognises the responsibility of regulatory Authorities in each EU member state in the determination of values related to safety matters at national level through a National Annex". NDPS are also used to give national geographic and climatic data.

In the Call for Experts for the different phases of the mandate (CEN, 2015) the following was included concerning the reduction of NDPs: "*The inclusion of NDPs in the published Eurocodes has been more extensive than was originally envisaged. All tasks concerned with existing Eurocode parts include a requirement to work to reduce the number of NDPs and enable better consensus on values adopted by Countries."*

The reduction of NDPs is a complex and delicate task and a specific CAP (Chairman Advisory Panel) was formed in TC250, to assist with the definition of guidelines for this specific objective, which were summarised in the TC250 Position paper on reducing the number of NDPs in the Structural Eurocodes (CEN/TC250, 2016).

The first problem to address is the detection of the NDPs for their potential elimination. This calls for the revision of the nature of the introduced NDPs and for a careful check about the degree of acceptance, in CEN countries, of the recommended values/procedures, offered in the Eurocodes.

As indicated in the foreword of the Eurocodes:

"The National Standards implementing the Eurocodes will comprise the full text of the Eurocodes (including any annexes), as published by CEN, and can be preceded by a National title page and National foreword and followed by a National Annex.

A National Annex can only contain information on those parameters, known as Nationally Determined Parameters (NDPs) that are left open in the Eurocodes for national choice. These NDPs are to be used for the design of buildings and civil engineering works to be constructed in the country concerned, i.e.:

- values and/or classes where alternatives are given in the Eurocodes;
- values to be used where a symbol only is given in the Eurocodes;
- country specific data (geographical, climatic, etc.), e.g. snow map;
- the procedure to be used where alternative procedures are given in the Eurocodes."

The first step is therefore the detection of those parameters which need to remain as NDPs, because of their nature and to focus on the remaining ones, seeking for consensus positions among different CEN member states.

The parameters that must be NDPs, even if all countries are adopting the same value, are:

- partial factors for materials and actions,
- the probability of the design seismic action being exceeded in a structure's design reference period,
- the time of fire exposure,
- design accidental actions,
- classification of structures in Consequences Classes corresponding to different Reliability Classes and levels, taking into account quality management requirements.

Other NDPs are being reviewed in an effort to try to reduce them in a pragmatical way, respecting the different positions of different CEN Members. NDPs relating to the following should be discouraged:

- technical issues, such as the choice of one mechanical model versus another, or one coefficient versus another in a resistance formulation,
- limits on geometric or similar parameters (e.g., size of cross section, upper or lower limits on reinforcement ratio or density) which have to do with limits of applicability of mechanical models,
- choice between advanced and simplified methods.

It is recognised that the reduction of NDPs should not impair the possibility to develop standards that can be implemented by CEN member states and to maintain consensus on the new generation of Eurocodes.

As stated above NDPs were widely used in the first generation of Eurocodes. Depending on the way to count them, approximately 1500 NDPs are distributed in the Eurocodes as shown in Figure 2.18.

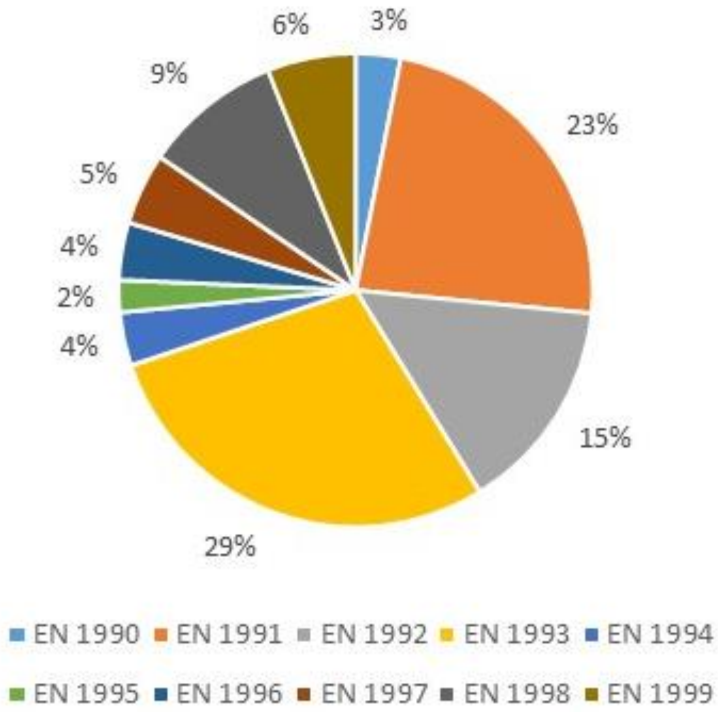

Figure 2.18 Distribution of NDPs in the different Eurocodes

Another key aspect in the reduction of NDPs is to detect those parameters for which a high level of consensus is reached in the National Annexes. To this aim the JRC, by means of the NDP Database, is keeping record of the degree of acceptance of the recommended values for the different NDPs in the Eurocodes, and the results are quite encouraging, as shown in Figure 2.19 (CEN/TC250, 2018). The updated edition of the JRC study is awaited in the beginning of 2019.

Finally, the availability of National Annexes for the first generation of Eurocodes allows the detailed comparison and consistency checks for climatic data, such as, for example, the snow maps.

Since the publication of the ENVs, the problem of consistency of climatic data along borders of neighbouring countries was discussed. Pre-normative research was carried out in the different fields to reduce inconsistencies, which are not caused by geographical reasons (such as mountain chains along the border), but most probably by different collection procedures, treatment and analysis of climatic data.

As an example, in the field of snow loads, a huge pre-normative research was developed in the years 1996-1999 leading to the European Ground Snow Load Map, covering 18 CEN countries, which at that time were the members of CEN, derived according to common statistical procedures (Sanpaolesi et al. 1996; 1999). This map was included in the informative annex C to the snow load part of Eurocode 1 (EN 1991-1-3) to serve as basis for national standard bodies to derive their own maps enhancing consistency at borders.

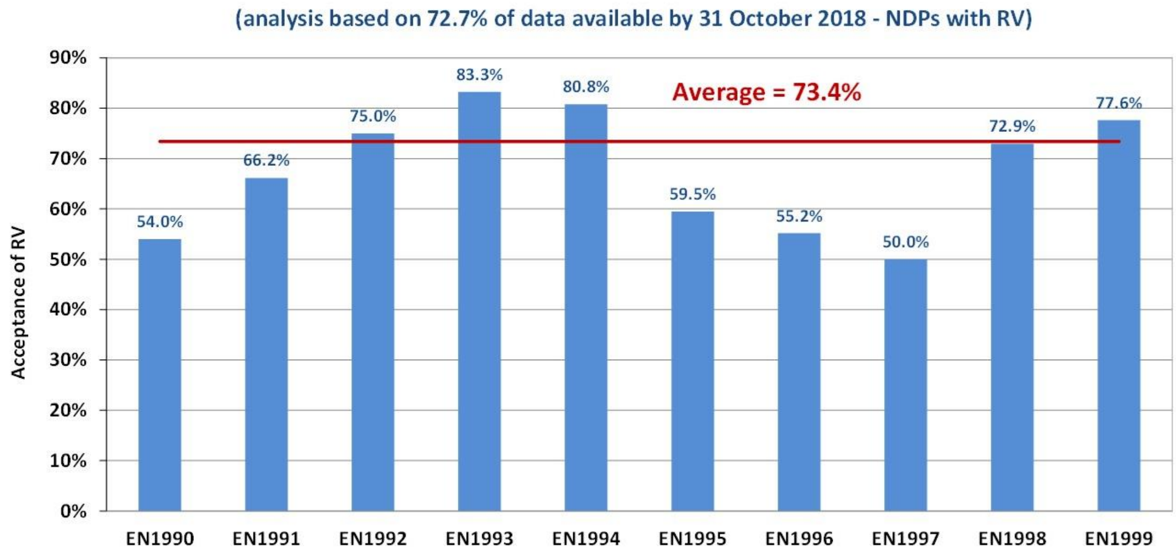

Figure 2.19 Acceptance of recommended values

It is now possible to "measure" the success of this initiative by comparing the ground snow load values provided in different National Annexes of CEN countries covered by the informative map provided in the EN 1191-1-3, with the map itself (Figure 2.20).

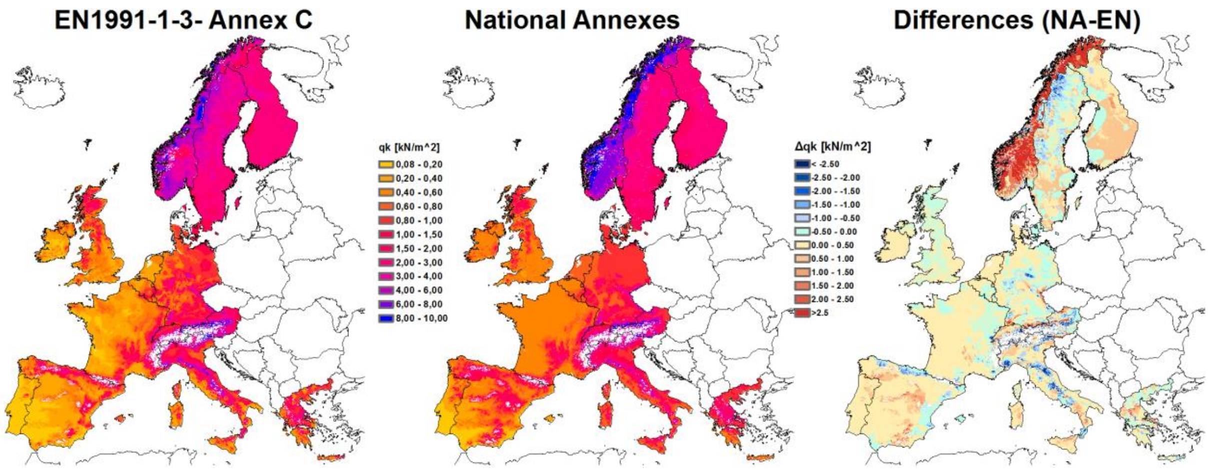

Figure 2.20 Comparison of ground snow load maps in NAs and Annex C to EN 1991-1-3 [© Paolo Formichi]

Differences in Figure 2.20 do not necessarily express lack of consistency, mainly because of the availability of more refined data, local investigation etc., but a general need for further checks, and possibly for further harmonised guidance on how to derive maps, is emerging.

This is confirmed also by the direct comparison of ground snow load values, calculated according to the National Annexes, at borders between neighbouring countries, as illustrated in Figure 2.21, where "French" and "German" ground snow loads are compared along the 450 km border line. To increase the harmonisation an in-deep study to understand the reasons for such inconsistencies is needed and is being carried out by the relevant Project Team.

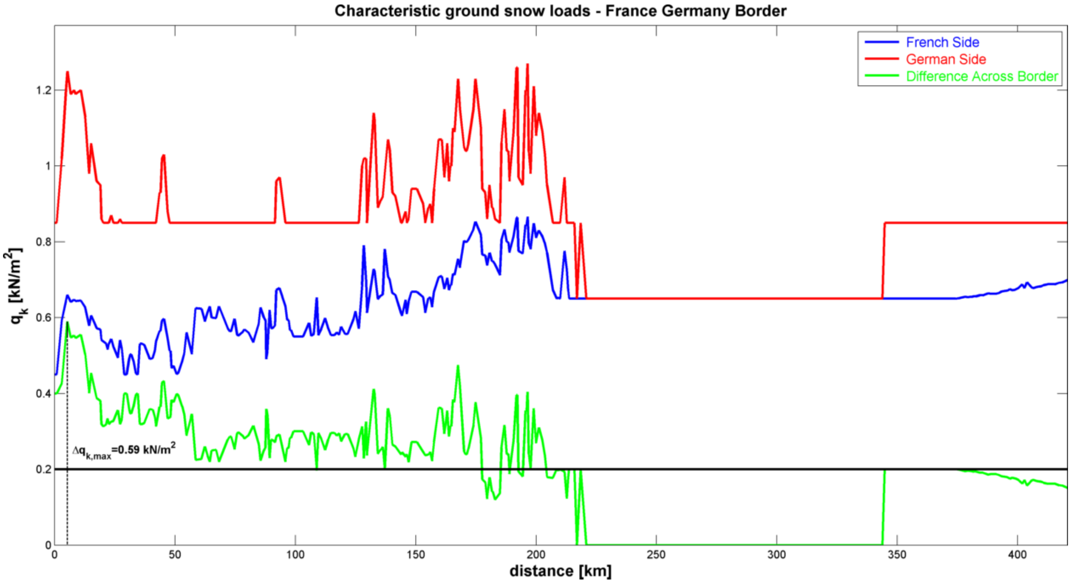

Figure 2.21 Comparison of ground snow load values at the border between France and Germany [© Paolo Formichi]

2.5 Conclusions

When the structural Eurocodes were first published as European (EN) Standards, prior to 2007, they were the most comprehensive and technically advanced suite of standards for structural and geotechnical design in the world. The Eurocodes are a tremendous achievement, resulting from over 30 years collaborative work by experts, National Standards Bodies and regulators across Europe.

In 2010, immediately after the date of withdrawal of conflicting national standards, the European Commission initiated the process for further evolution of the Eurocodes, to maintain this suite of standards fully up to date, to keep the long-term confidence in the codes and to embrace new materials, new methods and new regulatory and market requirements.

The work towards the "second generation" of the Eurocodes, as planned by CEN/TC250 according to the EC mandate M/515, started in 2015 and is currently underway, involving more than 1000 European experts in a project funded by the European Commission with approximately 11 million €. It is expected that the complete set of new standards will be in place by 2021-2023.

Further to the technical improvements and coverage's enlargement, the second generation of Eurocodes is being drafted, devoting particular attention to the needs of further harmonisation and ease of use for practical users.

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CHAPTER 3

THE IMPLEMENTATION OF THE EUROCODES IN THE EU: CASE STUDY – BELGIUM & LUXEMBOURG

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3 The implementation of the Eurocodes in the EU: Case Study – Belgium and Luxembourg

3.1 Introduction: Why National Annexes?

The Eurocodes are made up of 58 Parts which were published in 2002-2007 as European Standards (ENs). They contain still "Nationally Determined Parameters" (NDPs) for which the Eurocodes are only giving recommendations, and it is up to the National Standardization Bodies to publish National Annexes (NA) with, for each of them, national choices which may differ from the EN recommendations.

These NDPs are procedures, values, or classes recommendations, for which an agreement could not be reached within CEN TC 250 Sub-Committees. In all Eurocode Parts there are about 1500 NDPs, which are distributed as shown in Figure 3.1.

For each NDP, a NOTE in the EN standard indicates that a National choice should be given in a National Annex to this Eurocode Part. In addition, this NOTE gives a recommendation for a National choice that provides an acceptable level of reliability, so that the National Annex may refer to it or not as National choice.

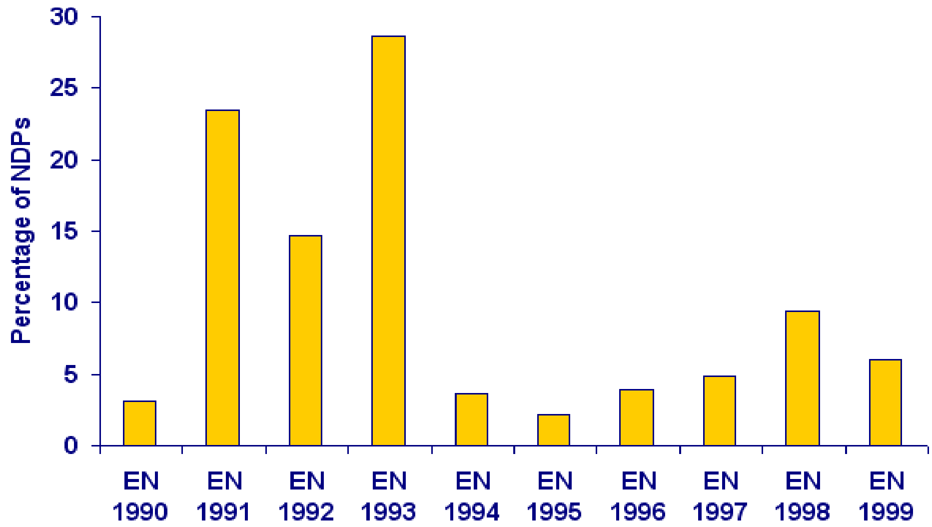

Figure 3.1 Distribution of Nationally Determined Parameters among the Eurocodes

3.2 Content of National Annexes

National Annexes may only contain information on those NDPs which are left open for National choice, as in the following cases:

- Values and/or classes where alternatives are possible;
- Values to be used where a symbol only is defined;
- Country specific data (geographical, climatic, etc.);
- Procedures to be used where alternatives are given.

Examples are shown in Figure 3.2 to Figure 3.5.

National Annexes may also contain:

- Decisions on the application of the informative annexes of a Eurocode Part to be normative, to remain informative or not to be applied;
- References to Non-Contradictory Complementary Information (NCCI) to assist the user to apply the Eurocode Part, which may concern e.g. cases not covered by the EN and for which figures, rules or guidance are needed for application on National level.

Table 6.2 – Imposed loads on floors, balconies and stairs in buildings

Categories of loaded areas	q_k [kN/m²]	Q_k [kN]
Category A		
- Floors	1,5 to 2,0	2,0 to 3,0
- Stairs	2,0 to 4,0	2,0 to 4,0
- Balconies	2,5 to 4,0	2,0 to 3,0
Category B	2,0 to 3,0	1, 5 to 4,5
Category C		
- C1	2,0 to 3,0	3,0 to 4,0
- C2	3,0 to 4,0	2,5 to 7,0 (4,0)
- C3	3,0 to 5,0	4,0 to 7,0
- C4	4,5 to 5,0	3,5 to 7,0
- C5	5,0 to 7,5	3,5 to 4,5
Category D		
-D1	4,0 to 5,0	3,5 to 7,0 (4,0)
-D2	4,0 to 5,0	3,5 to 7,0

Figure 3.2 Example of values from EN 1991-1-1 "Imposed loads" (ranges of values are defined and recommended values are underlined) [© CEN]

6.1.5 Simultaneity of uniform and temperature difference components

(1) If it is necessary to take into account both the temperature difference $\Delta T_{M,heat}$ (or $\Delta T_{M,cool}$) and the maximum range of uniform bridge temperature component $\Delta T_{N,exp}$ (or $\Delta T_{N,con}$) assuming simultaneity (e.g. in case of frame structures) the following expression may be used (which should be interpreted as load combinations):

$$\Delta T_{M,heat} \text{ (or } \Delta T_{M,cool}) + \omega_N \; \Delta T_{N,exp} \text{ (or } \Delta T_{N,con}) \qquad (6.3)$$

or

$$\omega_M \; \Delta T_{M,heat} \text{ (or } \Delta T_{M,cool}) + \Delta T_{N,exp} \text{ (or } \Delta T_{N,con}) \qquad (6.4)$$

where the most adverse effect should be chosen.

NOTE 1: The National annex may specify numerical values of ω_N and ω_M. If no other information is available, the recommended values for ω_N and ω_M are:

ω_N = 0,35

ω_M = 0,75.

Figure 3.3 Example of symbols from EN 1991-1-5 "Thermal actions" where a symbol only is defined [© CEN]

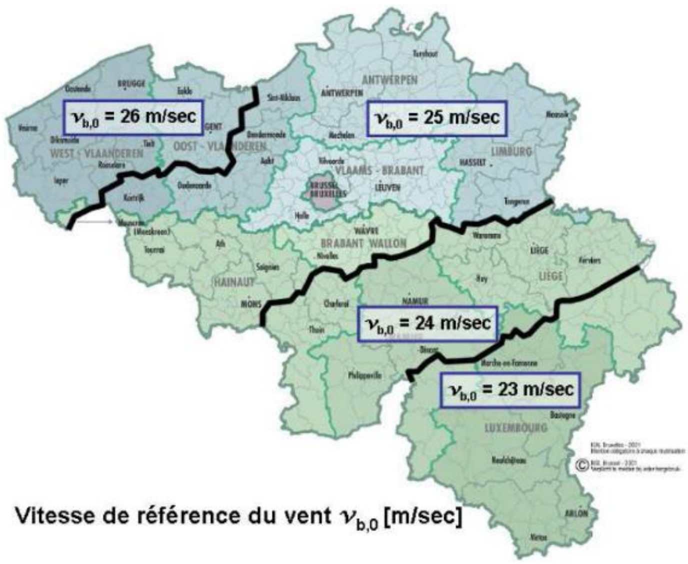

Figure 3.4 Example of country specific data from the Belgian National Annex to EN 1991-1-4: Wind [© Belgian Bureau for Standardization – NBN]

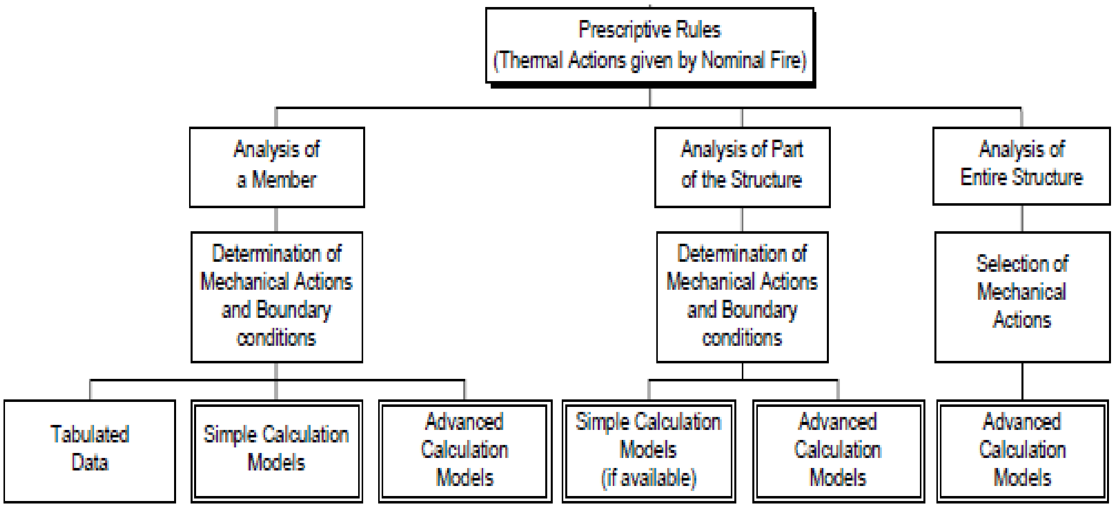

Figure 3.5 Example of alternative procedures from EN 1991-1-2 "Actions on structures exposed to fire" [© CEN]

3.3 Belgian National Annexes (NBN)

The Belgian National Annexes (ANB) have been drafted by 58 Working Groups (one for each Eurocode Part) including experts representing public authorities, designers (architects, engineers, etc.), contractors, industry and other interested bodies.

After reaching a consensus

- on the National choices for all NDPs,
- on the application of the informative annexes
- and, if needed, on the NCCI to be included in each ANB,

the projects were translated in Flemish and French and published as prANB by the Belgian Bureau for Standardization (NBN). The projects of ANB have been submitted to a public enquiry of 6 months. The Working Groups have then answered to the comments received, they have revised the projects accordingly, and the final versions were published as NBN standards before the end of 2011.

As an example of NDP, Figure 3.4 gives the map of the reference wind velocities to be used in Belgium when applying EN 1991-1-4 "Wind actions". In Annex E of the same standard, it is written that flutter instabilities of suspension-bridge decks occur above a certain critical wind velocity, and that flutter should be avoided, but no means to evaluate these critical wind velocities are given. Flutter instabilities are caused by the deflection of the structure modifying the aerodynamics to alter the loading, and may lead to collapse of the bridge, like it happened by torsional vibrations to the TACOMA bridge in 1940 (Figure 3.6).

NBN EN 1991-1-4 ANB:2010 is defining, as non-contradictory complementary information (NCCI), the critical wind velocities to be checked for possible aero-elastic instabilities of bridge decks (Figure 3.7). This NCCI has been used i.a. to check the design of the MILLAU bridge (Figure 3.8).

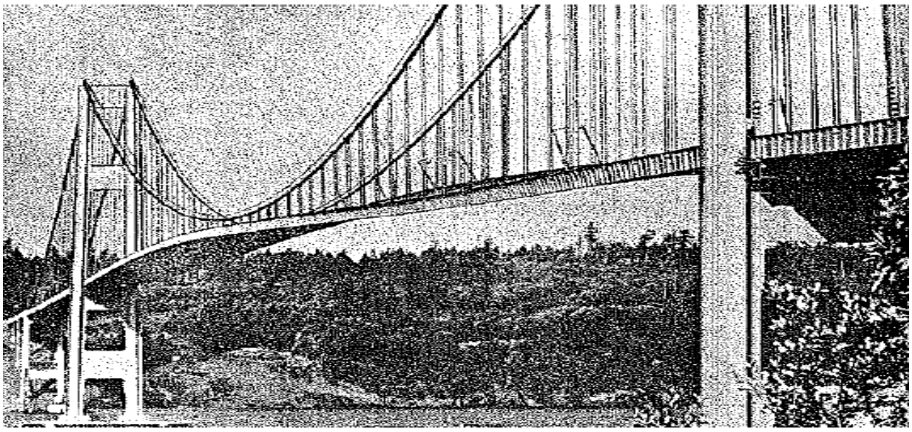

Figure 3.6 Torsional vibrations of TACOMA Bridge (1940) [Source: International Research Seminar on Wind Effects on Buildings and Structures, Ottawa, Canada, September 1967, Proceedings published by University of Toronto Press]

E.4.4.3 ANB Instability of bridges under pure bending (galloping)

$v_{cG} = 2.Sc.n_{1,f}.b / a_G$ (E.18)

E.4.4.4 ANB Instability of bridges under pure torsion (flutter)

$v_{cT} = n_{1,t}.d.\tau$ (E.32 ANB)

E.4.4.5 ANB Instability of bridges under both bending and torsion

$v_{c\varepsilon} = \pi.n_{1,f}.d.\beta.\eta$ (E.33 ANB)

where

v_{cG}, v_{cT}, $v_{c\varepsilon}$ are the critical wind velocities

Sc is the Scruton number

$n_{1,f}$ and $n_{1,t}$ are the natural frequencies of the first vibration mode of the bridge in bending and in torsion

b and d are the vertical and horizontal dimensions of the bridge deck section

a_G is the factor of galloping instability given in Figure E.12 ANB

τ is the factor of instability under torsion of the bridge deck given in Figure E.13 ANB

β is the factor of instability under both bending and torsion of a flat plate parallel to the wind direction given in Figure E.14 ANB depending on the ratio $\varepsilon = n_{1,t} / n_{1,f}$

η is the ratio between the critical velocity of the bridge deck section and the critical velocity of a flat plate parallel to the wind direction given in Figure E.15 ANB

Figure 3.7 Aero-elastic instabilities – Critical wind velocities (from NBN EN 1991-1-4 ANB:2010) [© NBN]

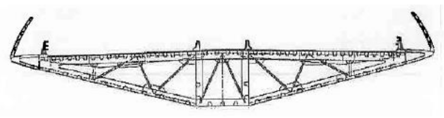

Figure 3.8 The MILLAU bridge (2013) [photo courtesy of Pierre Spehl]

3.4 National Annexes of Luxembourg

Since the beginning of the Belgium-Luxembourg Economic Union in 1921, Luxembourg has been using mostly Belgian standards, preferably to those of the two other neighboring countries, France and Germany, so that there was no National Standards Body existing when the European Commission requested the publication of the National Annexes to the Eurocodes. The "*Institut luxembourgeois de la normalisation, de l'accréditation, de la sécurité et qualité des produits et services*" (ILNAS) has been created in 2008 i.a. for this purpose.

In order to facilitate the drafting work and to spare time, only one Working Group of six Experts has been drafting the 58 projects of National Annexes for Luxembourg (AN-LU) on basis of the Belgian ones (ANB). This Group worked from December 2009 to Match 2010 and included four experts from Luxembourg and two Belgian experts from NBN/SECO.

The projects were published in June 2010 and submitted to a public enquiry until March 2011 (9 months). They are presented in tables giving for each paragraph the parameters defined at National level. As an example, the AN-LU to EN 1991-1-3 "Snow loads" is given in Figure 3.9.

The projects for which comments were received have been revised by the Working Group and the authors of the comments were invited to participate to the work from May to August 2011. The 58 National Annexes of Luxembourg (AN-LU) have been published as ILNAS standards in December 2011 and notified to the European Commission.

They may be freely downloaded in the 22 languages of the European Union on:

http://ec.europa.eu/growth/tools-databases/tris/en/search/

with the following inputs : (i) Year: 2010; (ii) Country: Luxembourg; and (iii) Product type: B00 : Construction.

Paragraph	Parameters defined at the national level
1.1(2) NOTE 1	Not applicable: the various altitudes within Luxembourg do not exceed 600 m.
1.1(3) NOTE 2	Case A contained in table A.1 of Annex A shall apply. The loads are not differentiated based on the applicable site conditions.
1.1(4) NOTE 3	Annex B shall not apply.
2(3) NOTE	Exceptional snow loads shall not apply.
2(4) NOTE	Exceptional accumulations of snow shall not apply.
3.3(1) NOTE 2	None of the project locations requires the application of exceptional conditions.
3.3(3) NOTE 2	None of the project locations requires the application of exceptional conditions.
4.1(1) NOTE 1	The characteristic value s_k (in kN/m²) of the ground snow load is defined by the expression (4.2 AN-LU) which is based on altitude A (in m): $s_k = 0.41 + A/966$ [kN/m²] (4.2 AN-LU) ***NON-CONTRADICTORY COMPLEMENTARY INFORMATION:*** ***The characteristic value s_k corresponds to a probability of 0.02, i.e. a return period of 50 years.***

Figure 3.9 Example of AN-LU to EN 1991-1-3 "snow loads" [© ILNAS]

3.5 Eurocodes and National Annexes as parts of the National legal systems

It is to be noted that the jurisdiction of the EU covers construction products, according to the Construction Products Regulation (CPR - Regulation (EU) No 305/2011), but does not cover construction works, which remain in the jurisdiction of the Member States and their regulatory authorities (Figure 3.10).

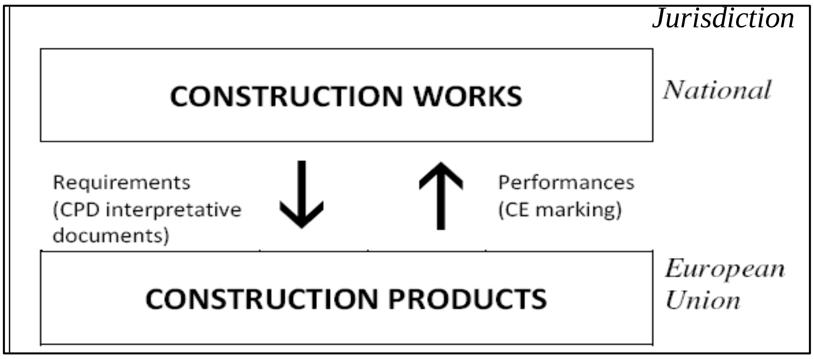

Figure 3.10 National and European jurisdictions according to the CPR

The first construction regulation in history has been the Code of Hammurabi which dates from 1760 BC (Figure 3.11): it covers safety of persons as well as safety of goods, and fixes already performance-based requirements i.e. requirements expressing the user's needs independently of the building materials and systems (Figure 3.12), together with (rather extreme!) penalties in case of failure.

*"If a builder builds a house for someone,
and does not construct it properly,
and the house which he built collapses
and kills its owner, then that builder
shall be put to death."* *(Art. 229)*

*"If it ruins goods,
he shall make compensation
for all that has been ruined,
and in as much as he did not construct
properly this house which he built
and it fell, he shall re-erect the house
from his own means."* *(Art. 232)*

Figure 3.11 Code of Hammurabi (1760 BC)

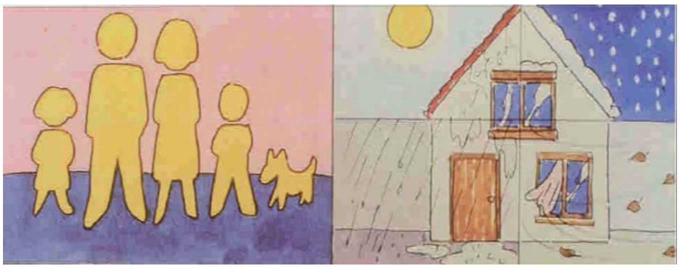

Figure 3.12 Performance-based requirements [Source: Guide des Performances du Bâtiment – Syndicat d'Etudes IC-IB, Brussels, 1980, Volume 1 – Le bâtiment dans son ensemble et ses espaces]

Since 1804, article 1792 of the Civil Code established by Napoleon (Figure 3.13), which is still the basis of the legal systems of several European countries, fixes the performance requirement as a 10-years liability of architects and contractors, but leaves to the Courts of Justice, not only the fixing of the penalties, but, before that, the evaluation of the responsibilities on basis of the "good practice" at the time of construction.

*"If the edifice, built at a set price, perish in whole or in part
by defect in its construction, even by defect in the foundation,
the architect and the contractor are responsible therefore
for ten years."* (Art. 1792)

Figure 3.13 Civil Code of Napoleon (1804)

Among the rules of good practice referred to in the Jurisprudence of the Courts, the Eurocodes will become, from now on, the dominating reference (but not the only one possible) for the stability and mechanical resistance of structures.

In Belgium for example, besides specific regulations on fire safety, dangerous goods and electrical, installations, article 1792, as it is, is still the only general construction regulation, and this leaves an applicability of standards (calculation methods e.g. Eurocodes) optimal freedom and a full responsibility to designers. But other European countries have established more detailed Building Regulations by law, and these have to be adapted in order to comply with the Eurocodes, which then become compulsory in these countries (Figure 3.14).

Source	**CIVIL CODE**	**LAW**
Technical requirements	**JURISPRUDENCE of the COURTS**	**REGULATIONS**
Application	**a posteriori**	**a priori**
Standards (e.g. Eurocodes)	**Referenced good practice but not compulsory**	**Compulsory only if imposed by regulation**

Figure 3.14 Applicability of standards

The universal nature of the Eurocodes means that they can be completed with national regulations and local customs. Regulations exist because there are those who will do "any odd thing" and against whom society should take precautions in the form of safeguards. Regulations are the expression of a culture at a given moment, and should represent the minimum consensus in the public interest.

Standards are clearly very useful as a common reference tool for all interested parties. They must exist, but they should not in the least diminish the responsibility of the persons who apply them, and it can be very dangerous to transform standards into regulations, so that thought is dispensed with, and an attitude of "if it's in compliance, it's okay!" prevails.

References

Guide des Performances du Bâtiment – Syndicat d'Etudes IC-IB, Brussels, 1980

International Research Seminar on Wind Effects on Buildings and Structures, Ottawa, Canada, September 1967, Proceedings published by University of Toronto Press

Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC OJ L 88 of 4 April 2011.

CHAPTER 4

THE IMPLEMENTATION OF THE EUROCODES IN THE EU: CASE STUDY - BULGARIA

Iren Dabizheva

Managing Director of the Bulgarian Institute for Standardization

4 The implementation of the Eurocodes in the EU: Case Study - Bulgaria

4.1 Policy

The Bulgarian Institute for Standardization[1] (BDS) and the Ministry of Regional Development and Public Works[2] (MRDPW) manage and provide together the national policy of the Bulgarian government for the implementation of European Standards under the former Construction Products Directive (CPD) and then the current Construction Products Regulation[3] (CPR) - Structural Eurocodes, Harmonized ENs and Supporting ENs, including determination of the Nationally Determined Parameters (NDPs) in respect to specific geographic, climatic and seismic conditions.

Technical Rules and Regulations Department at the Ministry of Regional Development and Public Works is responsible for:

- Full implementation of the CPR in Bulgaria; management of the creation of the National system of Conformity Assessment of construction products and designation of Approved and Approval Bodies (Notified Bodies).
- Organization and management of the elaboration of technical normative regulation for design and execution of building works, including structures, water-supply, sewerage, gas-supply, heating and ventilation systems and electrical installations.

4.2 General structure of the Bulgarian legislation

The legal framework for the elaboration of all technical rules and regulations related to design and execution of construction works is as follows:

- Spatial Planning Act[4] (SPA);
- Law on Chambers of Architects and Engineers in the Investment Design[5];
- Law on Technical Requirements to Products[6];
- Law on National Standardization[7].

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[1] http://www.bds-bg.org/en

[2] https://www.mrrb.bg/en/?lang=en

[3] Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC.
(https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011R0305).

[4] https://www.mrrb.bg/en/spatial-development-act/

[5] http://cpcp.mrrb.government.bg/cms/subsection-13-bylgarsko_zakonodate.html

[6] http://cpcp.mrrb.government.bg/cms/subsection-13-bylgarsko_zakonodate.html

[7] http://www.bds-bg.org/bg/button_52.html

4.3 Technical Committee BDS/TC 56 "Design of building constructions"

The Technical Committee BDS/TC 56 "Design of building constructions" was created in 1993 as a mirror committee on CEN/TC 250 and was initiated by the National Center of Construction (NCC).

Till the year 2000, the activities of BDS/TC 56 have been executed from NCC but after its disbandment (because of economical and other reasons), the institution proceeding the work in this area and providing financial support for the translation and technical editing of the Eurocodes is the Ministry of Regional Development and Public Works.

There is active participation in the activities of the BDS/TC 56 concerning the adoption of the European Standards by experts from:

- Technical Rules & Regulations Department – MRDPW;
- University of Architecture, Civil Engineering and Geodesy - UACG;
- High School of Building "Luben Karavelov";
- Varna Free University, Faculty for Architecture and Civil Engineering;
- Central Laboratory for Seismic Mechanics & Earthquake Engineering in Bulgarian Academy of Science;
- Research Institute for Civil Engineering;
- Bulgarian Scientific and Technical Union of Civil Engineering;
- National Agency "Road Infrastructure";
- Bulgarian Chamber of Engineers in the Investment Design;
- Chief Directorate Fire Safety and Civil Protection, Ministry of Interior;
- National Railway Infrastructure Company;
- Companies for production of construction products, such as Knauf, Wienerberger etc.;
- Design companies;
- Independent Experts.

4.4 Status of Eurocodes in Bulgaria

All parts of the ENV[8] Eurocodes have been translated in Bulgarian language and have been adopted as national standards. They have been published in the BDS Official Bulletin and can be found in the library of BDS (without National Annexes).

The engineering community had the opportunity to be acquainted with the ENV Eurocodes content and on this base to perform comparative calculations and design between the ENV Eurocodes and the Bulgarian Norms.

From the year 2003, Bulgaria started the process of adopting the Eurocodes in the phase of ENs. All 58 parts of the Eurocodes are implemented as Bulgarian standards BDS EN. All parts are translated into Bulgarian language and have been published from 2003 (BDS EN 1990) to 2013 (BDS EN 1999). All National Annexes have been published from 2011 to 2013.

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[8] ENVs - European pre-Standards.

In 2014-2015 all National Annexes were under systematic review. Several National Annexes have been revised and have new editions.

4.5 National Annexes and Nationally Determined Parameters (NDPs)

National Technical Committee BDS/TC 56 is structured like CEN/TC 250 – with 9 standing working groups (SWGs) which are mirror to TS 250 Sub-Committees (SCs) and 2 Horizontal Groups (HG) – "Fire" and "Bridges":

- In the SWGs, there have been involvement of prominent experts and professors from theory and practice in building engineering in Bulgaria.
- The experts have been appointed with the task of determination of the NDPs to the Eurocodes.
- Most of the NDPs have been determined in an expert way.
- For near 80% of the NDPs, the recommended values and classes have been accepted, with the exception of the climatic actions.

For the determination of some NDPs, there have been made comparative calculations.

Some of the national codes for structural design have been modified during last 10 years, drawing closer to the Eurocodes principles. Since 2004, *Ordinance Nr.* 3 *Basis of structural design and actions on structures* operates in Bulgaria. It implements in general EN 1990 and the parts of EN 1991.

The NDPs in EN 1990 and EN 1991 were considered with this Ordinance and with national experience, for example values for ψ - factors and γ - factors

The new seismic hazard map and maps of snow loads, wind and temperature have been prepared, with financial support of the Ministry of Regional Development and Public Works, by a team of prominent experts, mainly from the Bulgarian Academy of Science

4.6 Nationally Determined Parameters for Eurocode 8 (EN 1998)

As Bulgaria is one of zones with the highest seismic hazard in Europe, particular attention has been paid to EN 1998 (Eurocode 8: Design of structures for earthquake resistance).

Below is reported some data about the preparation of the National Annexes to the EN 1998 parts, from the report "*Definition of the National Parameters of the Eurocode 8"* delivered at the Balkan Seminar on earthquake engineering, 9-10 October 2009 in Sofia:

Quote:

[The total number of Nationally Determined Parameters in Eurocode 8 is more than 150. For nearly 80% of the NDPs the recommended values and classes were accepted but only after profound research and comparative calculations were made.]

4.6.1 NDPs for EN 1998-1: General rules, seismic actions and rules for buildings

Attention has been paid to the parameters related to the definition of seismic action. Data for the earthquakes from the seismic source in the Vrancha Mountain have been collected and a specific response spectrum has been developed. The territory to which this spectrum will be applied has been defined on the new Bulgarian seismic map.

Recommended values for the reference return period of seismic action for the no-collapse requirement as well as for the damage limitation requirement have been accepted due to the necessity for a harmonized approach to seismic hazard in all European countries.

Only the horizontal elastic response spectra type 1 was adopted in Bulgaria because the type 2 spectra is not typical for the local conditions in the country.

4.6.2 NDPs for EN 1998-2: Bridges

For five out of all the 30 NDPs in EN 1998-2, there have been proposed values and additional descriptions in the National Annex different from those recommended in EN 1998-2 on the basis of comparative calculations.

The proposals are balanced between the safety of the bridge and the higher expenses, taking into account the local conditions.

The definitions of the importance classes for bridges are more detailed on the basis of traffic capabilities, route importance, bridge height and fast traffic recovery capabilities.

4.6.3 NDPs for EN 1998-3: Assessment and retrofitting of buildings

Despite that there is no special design code for the assessment and retrofitting of buildings in Bulgaria, the existing practice is not completely different from the one described in EN 1998-3. The surveys and collection of information about the geometry, details and materials are the same as in the EN 1998-3.

The recommended values for return periods ascribed to the various Limit States in EN 1998-3 were accepted in Bulgaria after detailed analyses were carried out.

The recommended levels of inspection and testing are accepted, but a note is added for masonry buildings, for which a “case by case” approach should be taken.

4.6.4 NDPs for EN 1998-4: Silos, tanks and pipelines

In the NA to the Eurocode Part, two different values for horizontal and vertical directions are proposed for the maximum value of the radiation damping.

For the determination of the overstrength factor on the design resistance of the piping, a numerical finite element model has been made and the recommended value has been adopted.

4.7 Relation between Eurocodes and hEN/ supporting standards under CPD/CPR 305/2011

According the last list of the Harmonized European Standards (hEN) under CPR, published in OJ 09/03/2018, they are in total 444 (ex. Corrigenda). All of them are implemented as BDS EN. 270 (60%) of them are translated and published in the Bulgarian language.

Many of the supporting standards, containing test methods, are also translated in the Bulgarian language, for example for testing cement, concrete, steel materials, mortars, masonry units, insulations etc. The links between the EN Eurocodes and related European standards for concrete structures are shown schematically in Figure 4.1.

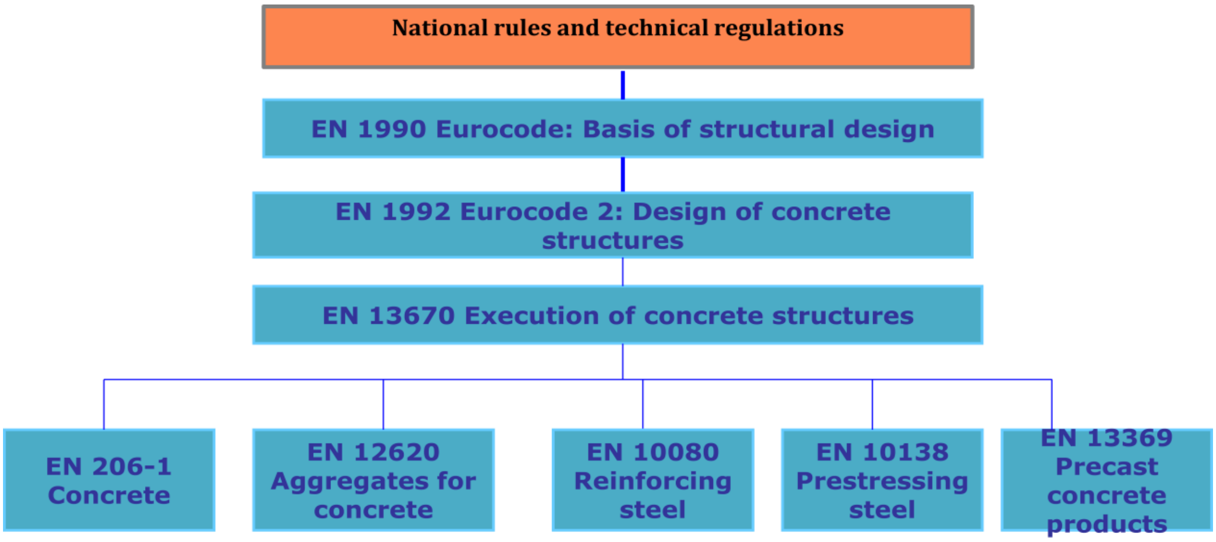

Figure 4.1 Example for the links between the EN Eurocodes and related European standards for concrete structures

For the main product standards for concrete production, National Annexes were elaborated as listed below:

- BDS EN 206-1:2002/NA:2008 and BDS EN 206:2013+A1:2016/ NA:2017 - Concrete
- BDS EN 12620:2002+A1:2008/NA:2008, NA:2015, NA:2017 - Aggregate
- BDS EN 197-1:2011/NA:2013 - Cement
- BDS EN 13670:2009/NA:2015 - Execution
- BDS EN 13791:2007/NA:2011 - In-situ compressive strength of concrete
- BDS EN 450-1:2012/NA:2013 - Fly ash for concrete
- BDS EN 934-2:2009+A1:2012/NA:2013 – Admixtures for concrete
- BDS EN 14889-1:2006/NA:2013 - Steel fibres for concrete
- BDS EN 14889-2:2006/NA:2013 – Polymer fibres for concrete
- BDS EN 15167-1:2006/NA:2015 - Ground granulated blast furnace slag
- BDS EN 934-3:2009+A1:2012/NA:2015 - Admixtures for masonry mortar
- BDS EN 934-4:2009/NA:2015 - Admixtures for grout for prestressing tendons
- BDS EN 934-5:2008/NA:2013 - Admixtures for sprayed concrete
- BDS EN 998-1:2010/NA:2013 - Mortar for masonry – rendering and plastering
- BDS EN 998-2:2010/NA:2013 – Masonry mortar
- BDS EN 13748-1:2004/NA:2014 - Terrazzo tiles for internal use
- BDS EN 15050:2007+A1:2012/NA:2013 - Precast concrete bridge elements

Generally in BDS, 170 National Annexes in construction sector are developed, including:

- 60 acting NAs to Eurocodes, 7 revised, 6 drafts for revision, 2 Amendments;
- 110 acting NAs to harmonized standards for construction products, 19 drafts.

4.8 The Eurocodes and NAs in Bulgarian Legislation

The main normative document for implementing the Eurocodes in the national regulatory framework is Ordinance N RD-02-20-19/29 December 2011 on the structural design of civil engineering structures of buildings and construction facilities by applying Eurocodes, in force from 6 January 2015 (after transitional period).

This Ordinance shall be implemented for structural design of public buildings and civil engineering works, subject of public procurement.

Exceptions:

- For buildings of 3 to 5 category, assigned from private investors;
- For retrofitting and reconstruction of existing buildings and civil engineering works.

In the above mentioned situations, the buildings may be designed according to the Bulgarian norms or according to the Eurocodes, depending on the investor assignment.

4.9 Education

Education for students – in high schools for structural design:

- University of Architecture, Civil Engineering and Geodesy (UACG);
- High School of Building "Luben Karavelov";
- Varna Free University.

The education for engineers-designers is performed by courses delivered by the Chamber of Engineers in the Investment Design (CEID). There are guides for the design of structures according to the Eurocodes, elaborated with financial support of the Chamber of Engineers in the Investment Design.

For the educational purposes, BDS ensures:

- Collection of all Eurocodes parts at most reduced prize for CEID members;
- Collection with over than 60 harmonized standards for construction products at most reduced prize for CEID members.

4.10 Cooperation with Universities

BDS opened the Information Centers in several Universities in Sofia and in other cities. There students have the possibility to read standards on the computer screen, free of charge.

The Universities, which have signed Agreement with BDS, have the following obligations:

- to participate in standardization activities with experts in those BDS/TCs whose standards would like to read;
- to include in educational programs knowledge about standards and standardization;
- to keep BDS intellectual property and exploitation rights on the standards.

Currently, there are 11 such Information Centers functioning in different universities in Bulgaria.

At the 37th ISO General Assembly in Rio de Janeiro (2014), BDS experts shared the experience on the functioning of the Information Centers in Universities.

This was recognized as good practice at international level and was described in the ISOfocus magazine of May/June 2015[9].

The ISO community recognized that this is an important step for promoting the standardization among faculty and students. It was also noted that incorporating standards into a university curriculum provides an excellent introduction to the impact of standardization on the marketplace and gives young graduates a competitive edge when entering the workforce.

[9] https://www.iso.org/isofocus_110.html

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Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC.

CHAPTER 5

THE IMPLEMENTATION OF THE EUROCODES IN THE EU: CASE STUDY - CROATIA

Vlasta GAĆEŠA-MORIĆ

Croatian Standards Institute (HZN)

5. The implementation of the Eurocodes in the EU: Case Study - Croatia

5.1 Presentation of the Croatian Standards Institute (HZN)

The Croatian Standards Institute[1] (HZN) is the National Standards Body of the Republic of Croatia.

It was established by the "Decree of the Government of the Republic of Croatia on the establishment of the Croatian Standards Institute" (NN 154/2004; NN 44/2005; NN 30/2010; NN 34/2012; NN 79/2012) based on the "Law on Standardization" (NN 80/2013) and started its work on the 1st of July, 2005.

Five years later, in the beginning of 2010, HZN became a full member of CEN & CENELEC.

On the 1st of July 2013, Croatia became a full member of European Union.

5.2 Croatian Approach to the Adoption and Implementation of the Eurocodes

During the process of preparation for the membership in CEN & CENELEC, HZN had to adopt all European Standards as Croatian Standards, consequently all 58 parts of the EN Eurocodes, the European standards for the design of structures.

This task was very demanding because National Annexes had to be prepared as a tool for the implementation of the Eurocodes at the national level. Considering the number of Nationally Determined Parameters (NDPs), it was obvious that this task would require extensive help by institutions directly interested in the Eurocodes implementation.

Luckily, both the Ministry of Construction and Physical Planning and the Croatian Chamber of Civil Engineers expressed full understanding for this process and interest in supporting it actively and financially.

On the Chamber's initiative, on the 5th of September, 2007 both organizations and HZN signed the Agreement on Cooperation in the Process of Adoption of the Eurocodes as Croatian Standards[2]. For the realisation of the Agreement, the detailed Work Plan on Adoption of the Eurocodes as Croatian Standards for the Period 2008 – 2010[3] was prepared. This document was the basis for signing annual bilateral contracts between the responsible Ministry and HZN and between the Chamber and HZN.

The Work Plan was not realized on time and was postponed several times for various reasons: lack of awareness and commitment of members at the high management level, insufficient capacities (human resources within HZN), difficulties with reaching consensus on certain NDPs and time consuming work on new maps for climatic actions on structures and seismic impact, as the existing maps were very old and inapplicable.

[1] https://www.hzn.hr/default.aspx?id=435

[2] Not publicly available document, internal HZN documents in Croatian language

[3] Not publicly available document, internal HZN documents in Croatian language

5.3 HZN/TO 548 Structural Eurocodes

5.3.1 Establishment

The assignment of adopting the Eurocodes and developing the corresponding National Annexes was given to HZN/TO 548, Structural Eurocodes, the National Mirror Committee to the European CEN/TC 250 "Structural Eurocodes". HZN/TO 548[4] was established on the 28th November 2006 with mirroring substructure as TC 250: 9 subcommittees (POs[5]). It also had 3 working groups: RS 1 – Translation, RS 2 - National Annexes, and RS 3 - Eurocode 0[6].

HZN/TO Subcommittees have the same field of activities as the corresponding TC 250/SCs.

Working group RS 1 - Translation was established for the purpose of developing Croatian terminology relating to the Eurocodes which should be used in all parts of the Eurocodes. The task of working group RS 2 - National Annexes was to create a unified architecture for all NAs to be recognized and make them as user-friendly as possible. Working group RS 3 - Eurocode 0 was created to deal with activities related to EN 1990. After having completed the translation and publication of all parts of Eurocodes and the corresponding NAs, all three working groups were disbanded.

After the establishment of TC 250/SC 10 (EN 1990 Basis of structural design), and TC 250/SC 11 (Structural Glass) at the European level, the corresponding Croatian subcommittees were established within TO 548 in early 2016 with the same field of activities.

As the work on Eurocodes previously had been done within several different TCs, with establishment of HZN/TO 548 with such substructure, conditions for organized and planned work on all Eurocodes within single TC had been provided. Currently, 137 experts from different institutions and firms are involved in its work.

5.3.2 Development and publication of HRNs

At the beginning of its work, HZN/TO 548 made several basic decisions on how to approach its demanding task. For the sake of fulfilling the condition of adoption of all European standards, TO 548 decided to first adopt all Eurocodes in original (English) and then translate them into Croatian. National Annexes (NAs) were to be developed and published as separate documents as soon as possible.

The first editions of all 58 parts of Eurocodes (with all corresponding amendments and corrigenda) were published in 2008 (HRN EN 199x:2008) as Croatian standards in English.

The second editions were published between 2011 and 2015 in the Croatian language. To make them user-friendly, these Croatian standards were published as consolidated versions including all European amendments and corrigenda published before the date of their publication.

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[4] TO stands for "tehnički odbor" (technical committee) in Croatian language

[5] PO stands for "pododbor" (subcommittee)

[6] RS stands for "radna skupina" (working group)

This approach was user-friendly but it also raised some problems. New amendments and corrigenda continued to appear, but HZN did not have enough capacity to consolidate them after every new corrigenda publication. Thid resulted in the publication of these amendments as separate Croatian standards (14 amendments). They have all been translated into Croatian. However, this procedure is neither transparent enough nor user friendly enough anymore.

5.3.3 Development and publication of NAs

During the process of preparing translated and consolidated Eurocodes, Croatian National Annexes were developed and prepared to be published at the same time as standards. So, with the publication of each part of Eurocode, the corresponding NA was published, too. 57 parts of NAs (without NA to HRN EN 1997-2) were published between 2011 and 2015. In the beginning, they were published in Croatian, but afterwards also in English. They are presently all available in both lan.guage versions (hr & en).

Croatian NAs contain new maps for climatic actions on structures: map of snow areas (HRN EN 1991-1-3/NA), map with fundamental value of the basic wind velocity (HRN EN 1991-1-4/NA) and two maps of maximum/minimum shade temperature (HRN EN 1991-1-5/NA). All these climatic maps are based on 30-years period records (1971 – 2000). They have been created by the Croatian Meteorological and Hydrological Service[7].

Croatian National Annex HRN EN 1998-1/NA contains two new seismic zone maps for reference peak ground acceleration for return periods of 475 years and 95 years. They were developed by the University of Zagreb, Faculty of Science, Department of Geophysics and available also in interactive version.

All maps are also available in larger scale and can be purchased separately.

The share of accepted recommended values of Nationally Determined Parameters (NDPs) in Croatian NAs is between 48 % (HRN EN 1994/NA) and 100 % (HRN EN 1999/NA), on average ~80 % for all parts.

Due to the publication of new Eurocode amendments, some NAs had to be updated in accordance with the new or modified NDPs. Eight updated NAs have been published so far. They have all been translated into English and are available in both language versions.

All Croatian NDPs are regularly uploaded in the JRC Eurocodes NDP Database by the responsible national authority, the Ministry of Construction and Physical Planning.

5.4 Implementation of the Eurocodes in Croatia

The implementation of Croatian standards is achieved by means of technical regulations prepared by the Ministry of Construction and Physical Planning.

The Eurocodes are implemented by the Technical regulation for building structures, published in March 2017. It is a single regulation for all types of structures which replaced previous six regulations, one for each type of structure (concrete, steel, composite steel and concrete, timber, masonry and aluminium). The Eurocodes are listed in the Technical regulation as a best way for fulfilling basic requirements for structures.

[7] http://meteo.hr/index_en.php

5.5 Further activities

Present and future activities on Eurocodes are based on M/515 Mandate for amending existing Eurocodes and extending the scope of structural Eurocodes. They are focused on active participation of Croatian experts in the development of their new generation.

Croatian experts regularly participate in the meetings of some TC250/ SCs, namely SC5, SC 9 and SC 11. 14 experts actively participate in certain working groups (WGs): in the field of timber structures, aluminium structures and structural glass, which is a new field of activity.

Furthermore, focus is given on preparatory work for the development of NDPs within future National Annexes on the second generation of the Eurocodes. It primarily involves preparing for the design of new climatic and seismic maps which are to be incorporated in the NAs. Considering climatic changes, new climatic maps should be based on a more recent 30-year period.

CHAPTER 6

THE IMPLEMENTATION OF THE EUROCODES IN THE EU: CASE STUDY – THE CZECH REPUBLIC

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6. The implementation of the Eurocodes in the EU: Case Study – the Czech Republic

6.1 Introduction

The EN Eurocodes were fully implemented into the system of Czech standards for structural design in 2010 and all National Determined Parameters (NDPs) were selected according to the schedule given in the Guidance Paper L[1]. Previously used conflicting national standards for structural design were withdrawn. National Annexes (NA) to Eurocodes have an informative statute, however the NDPs have normative character for the design of structures in the Czech Republic.

Selected original Czech standards have been revised as some technical issues are not fully covered by Eurocodes, e.g. actions on water construction works, atmospheric icing on structures, actions due to trams and metro on bridges, design of structures on mining subsidence areas, assessment of existing structures.

Recently, several standards for static and dynamic testing of structures have been also revised in order to be harmonised with the methodology given in Eurocodes. The standard for the design of structures made of polymers has been under development.

The Czech Technical Standards (CSN) are not mandatory documents for structural design in the Czech Republic. However, they can become mandatory under relevant conditions, e.g. based on a decision of responsible authorities or on the basis of a contract between the contractor and client.

For the national implementation of Eurocodes and their operational application for structural design, the amendment of national building regulations was needed.

6.2 Building regulations

The Building law No. 183/2006 with its several amendments is to be applied for buildings. For its operational applications, the Directive 168/2009 is developed where basic requirements for construction works are requested.

[Quote]

"Construction works shall be designed and executed in accordance to "standardised values" in such a way that the load effects and adverse influence of environment to which the structures are subjected during execution and their use with regular maintenance could not lead to:

a) *Sudden or progressive collapse or other destructive damage of any part of a structure or adjacent construction works,*

b) *Non acceptable deformations or vibrations of structure which could violate the stability of structure, mechanical resistance and serviceability of construction works or its part leading to reduction of durability of structures,*

c) *Damage or jeopardize of serviceability of connected technical devices due to the deformations of load bearing structure,*

[1] Guidance Paper L on the Application and Use of the Eurocodes relates to the Construction Products Directive - 89/106/EEC.

d) Endanger of serviceability of infrastructure near construction works,

e) Endanger of serviceability of technical installations near construction works,

f) Failure of structures to an extent disproportionate to original cause, in particular by explosion, impact, overloading, gross human error which could be prevented, or to manage to reduce them,

g) Failure of structures due to adverse effects of ground waters evoked by increase or decrease of water level of adjacent river or dynamics damages by flooding, or upward hydrostatic pressure during flooding,

h) Endanger of the rate of flow of river channel, possibly also bridges and culverts".

Regulation No. 268/2009 for implementation of the Building law requires to fulfil "standardised values" which include individual technical requirements, in particular some constrain, design value, technical properties of materials (i.e NDPs in Eurocodes). They are given in the relevant Czech technical standards (CSN) which fulfilment is assumed to be important for the accomplishment of the requirements of the Regulation.

Regulation No. 268/2009 is applied for buildings only. It should be noted that this regulation is not valid for the capital city of Prague where another regulation is to be used (Prague building regulations). Prague city regulations make reference to whole standards, not only to standardised values. Thus, some inconsistencies in the national regulations for buildings still remain.

Law No. 13/1997 on road communications and Regulation No.104/1997 for its implementation is valid for highways and roads. The Ministry of Transport established the Road administration office for highways, the regional offices for class I roads, the municipality for class II roads and a council for local roads of III class.

Regulation No.104/1997 provides rules on how to fulfil basic requirements for civil engineering works based directly on the Czech standards (CSN) and other prescriptive documents (without giving references on standardised values). Annex 9 of this regulation provides the minimum required scope and extent of the project documentation (drawings, structural analysis, technical report) for highways and roads of different categories.

Project documentation for execution of construction works of roads specifies requirements from both technical and resulting qualitative requirements. It shall be developed to details univocally specifying the subject of construction works and their technical properties. Thus, in such way it is possible to be used for a list of works for determination of costs for the realisation of relevant civil engineering works.

Czech technical standards, technical requirements and other documents agreed and published by the Ministry of Transports of the Czech Republic are applied for the design and execution of bridges, tunnels and other civil engineering works on roads on the basis of contract. In this way, the CSNs are becoming obligatory documents for the design and construction of individual construction works.

6.3 Development of National Annexes

National Annexes to the current generation of Eurocodes have been developed in the Czech Republic on the basis of the schedule given in Guidance Paper L and also in other documents published by the Technical Committee "Structural Eurocodes" CEN/TC 250. Translations, calibrations and comparative studies were co-ordinated by the Czech Office for Standards, Metrology and Testing (UNMZ) and the Czech Technical Standardisation Committee TNK 38. Several research institutions, technical universities and the Czech Chamber of Civil Engineers (CKAIT) were involved in the process of implementation of the

Eurocodes in the Czech Republic. The Centre of Technical Standardisation (CTN) for reliability and actions on structures was established in the Czech Technical University in Prague, Klokner Institute under the contract with UNMZ. CTN supports the implementation of the Eurocodes in the Czech Republic and it is involved in the translation of the Eurocodes to Czech language, the development of the National Annexes and the uploading of all NDPs to the JRC NDPs database.

National Annexes to the Eurocodes have informative character in the Czech Republic; however nationally selected NDPs have normative character for structural design.

6.4 Implementation of selected Eurocodes

Selected National Annexes and their NDPs from Eurocodes EN 1990 and EN 1991 are shortly introduced as follows. It should be noted that the informative or normative statute of all annexes given in Eurocodes was not changed at national level. It should be mentioned that only few informative annexes are not applied in the Czech Republic.

6.4.1 EN 1990 Basis of design

Eurocode EN 1990 is the fundamental standard for structural design. Main NDPs that had to be more deeply analysed in the Czech Republic included the three alternative combinations of actions for the verification of Ultimate Limit States and three geotechnical approaches.

Comparative analyses and calibration studies were worked out in the Technical Committee TNK 38 which closely co-operates with the Czech Agency for Standardisation CAS (one section of UNMZ). It was recommended on the basis of calibrations that for the determination of fundamental combination of actions, the less favourable of the twin expressions (Eq. 6.10a), (Eq. 6.10b) is to be applied. The application of the combination of actions according to the twin expressions gives in common cases more uniform reliability level of structures for various ratios of the characteristic values of variable loads to total loads. As an alternative, a combination of actions according to the expression (6.10) may also be used. This combination may nevertheless lead to the less economical solution.

Recommended values of partial factors and combination factors were nationally accepted.

An example of reliability analysis of selected structural members is illustrated in Figure 6.1 for three alternative combinations of actions [exp. (6.10), (6.10a, 6.10b) and (6.10amod, 6.10b) are denoted here as expressions (a), (b) and (c)] as a function of the load ratio χ between the characteristic values of variable actions to total loads. For further details, see the report by Markova et. al. (2018).

EN 1990, Annex A recommends that the design of structural members for the limit states (type STR) involving geotechnical actions and the resistance of the ground (GEO) should be verified using one of the three geotechnical procedures. The geotechnical procedure can be nationally selected. Technical committees TNK 38, focused on structural reliability, and TNK 41, aimed at geotechnical structures, analysed in co-operation three alternative approaches. They decided to keep all three geotechnical approaches for structural design in the Czech Republic without giving any preference.

The National Annex to EN 1990 provides guidance to select the best procedure for the modelling of the conditions of an analysed structure, considering all information which can influence the reliability of the structure. Generally, if it is not known in advance which procedure is to be used, then the structural member should be verified according to all three geotechnical procedures. The less favourable alternative is the decisive one.

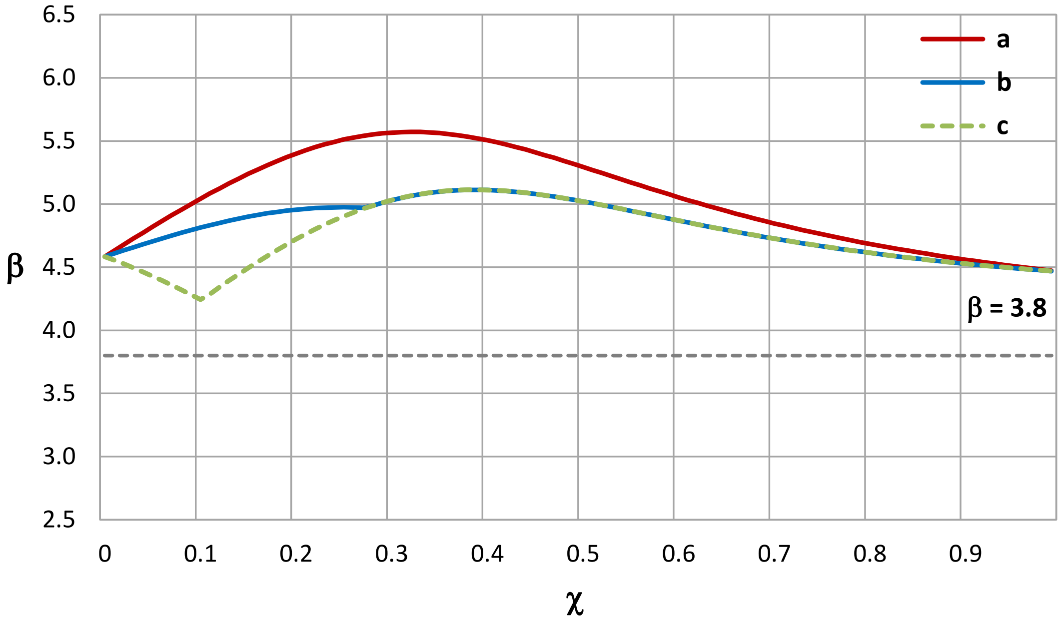

Figure 6.1 Reliability index β of a reinforced concrete beam as a function of the load ratio χ, for upper bound of imposed load of category B recommended in EN 1991-1-1 (Markova et al., 2018)

It was recommended that for buildings, the procedure 3 may be commonly applied for the design of footings; for the design of piles and for the assessment of the stability of slopes the procedure 2 may be applied; lastly, for the calculation of a soil pressure, the procedure 3 should be used. For bridges, the design procedure 2 was recommended in the Czech Republic.

Obviously, in addition to structural reliability, several other aspects should also be taken into account in national decision about NDPs. For example, due attention should be payed to economical, ecological and other consequences including laboriousness, time consumption, and transparency of design analysis.

6.4.2 EN 1991-1-1 Densities, self-weight and imposed loads for buildings

The National Annex gives NDPs and additional information required for the determination of densities of stored and construction materials, products, self-weight of structures and imposed loads for buildings that are used for the structural design of construction works according to the EN 1991-1-1 in the Czech Republic. In addition, it provides the decisions concerning application of Annexes A and B.

Categories of use for residential, social, commercial and administration purposes remain unchanged in the Czech Republic. Depending on their anticipated use, areas likely to be categorised as C2, C3, C4 may be categorised as C5 by contract with the client. Characteristic values of imposed loads were selected from recommended ranges considering also previous national design tradition. Supplementary information is given for imposed loads in industrial rooms and storage areas, and also for temporary structures.

6.4.3 EN 1991-1-3 Snow loads

Procedure for the determination of snow on the lower roof was amended considering national conditions. Problems with the collapse of roofs during winter 2005/2006 resulted in the development of the new ground snow map based on newly statistically evaluated data from 1961 till 2005 years and considering a 50 year return period. Previous Czech snow load map given in previous national codes was based on a 15 year return period only. Annex B is not used and the exceptional snow load drift is not specified in Czech Republic.

6.4.4 EN 1991-1-4 Wind actions

Various comparative studies of wind models given in previous Czech codes and in EN 1991-1-4 were worked up to decide about the related NDPs. The new map of basic wind velocity is based on a 50 years return period (the original Czech map was based on a 15 year return period only). The wind zones are selected with the fundamental values of the basic wind velocity ($v_{b,0}$) of 22,5 m/s, 25,0 m/s, 27,5 m/s, and 30,0 m/s. In regions with $v_{b,0}$ > 30 m/s, the fundamental value of the basic wind velocity for particular localities shall be specified on the basis of the recommendation by CHMI (Czech Hydrometeorological Institute). It should be noted that the design of structures according to the EN 1991-1-4 is commonly significantly complex in comparison to previously used national codes (presently leading often to considerably bigger internal forces). It was decided about alternative approaches in EN 1991-1-4 and Annex C is not used in the Czech Republic.

6.4.5 EN 1991-1-5 Thermal actions

The National Annex gives the NDPs required for the specification of thermal actions on buildings and civil engineering works that are used in design of construction works according to the ČSN EN 1991-1-5 in the Czech Republic. Development of new maps with maximum and minimum shade air temperature are based on a 50 years return period. For bridges, the non-linear approach 2 for the temperature differential profile is applied in the Czech Republic.

6.4.6 EN 1998 Seismic actions

Seismic actions are needed to be considered in some regions of the Czech Republic. The original national code consisted of about 30 pages while presently EN 1998 includes more than 500 pages that is demanding for Czech designers. A new map of seismic zones has been recently updated giving reference peek acceleration from 0,03 a_{gR} till 0,07 a_{gR} on ground type A.

6.4.7 Assessment of existing structures

For the assessment of existing structures, apart from Eurocodes which are intended mainly for new structures, supplementary rules are needed. Therefore, the international standard ISO 13822:2010 "Bases for design of structures -- Assessment of existing structures" was implemented in the Czech Republic in 2005. Several National Annexes have been developed and published in CSN 73 0038 where supplementary information on properties of structural materials from the beginning of 20th century is given. New revised versions of both documents were published on 2014, supplemented by information on historical structures preserved as monuments.

6.5 Concluding remarks

Implementation of Eurocodes into the system of national codes brings various advantages for trade, co-operation, availability of an advanced system of standards with regular maintenance.

National resources are needed for the efficient implementation of the Eurocodes. The theoretical bases of Eurocodes should be taught at technical universities. Hanbooks and software for structural analyses according to Eurocodes should be made available.

For operational applications of the Eurocodes, basic requirements on construction works should be given in national regulations with references to the Eurocodes.

Further evolution of Eurocodes has started in Technical Committee CEN/TC 250 and its subcommittees SC1 to SC11 which should contribute to the preparation of new Parts of the Eurocodes and simplification of their application for common types of structures.

Czech experts are activelly involved in the process of further evolution of Eurocodes and they regularly comment working drafts of new Parts of Eurocodes. This will facilitate national decisions on the NDPs in the 2nd generation of Eurocodes.

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CHAPTER 7

THE IMPLEMENTATION OF THE EUROCODES IN THE EU: CASE STUDY - FRANCE

Jean-Armand CALGARO

Honorary General Engineer of Bridges and Roads

7 The implementation of the Eurocodes in the EU: Case Study - France

7.1 General background on the Eurocodes development and implementation

The CEB (in French "Comité Européen du Béton") was founded on 6 November 1953. Immediately, many countries participated to the development of this association and many experts started working to establish recommendations. Thus, the first International Recommendations CEB/FIP[1] were published in 1970. But the major document by CEB has been the CEB Model Code, published in 1978 (MC 78). It included 2 Parts: Part I was devoted to developments in the field of structural safety and was established with the participation of JCSS[2]. It was intended to cover all materials and all types of structures. Part II was devoted to the design of reinforced concrete construction works.

After the publication of the Public Procurement Directive 71/305/CE, the European Commission appointed a steering committee to establish a set of documents, called Eurocodes, allowing the judgement of an international calls for tenders. The development of the Eurocodes started in 1975, as a result of the decision of the Commission of the European Community to embark on an action programme in the field of construction based on Article 95 of the Treaty of Rome. The objective of the programme was the elimination of technical obstacles to trade and the harmonisation of technical specifications by means of technical rules which, in the first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them. Part I of the MC 78 was the basis of the semi-probabilistic approach of reliability, which was adopted for all Eurocodes.

After the publication of the Construction Product Directive (CPD – 89/106CEE), the transformation of the first set of documents into European standards was assigned to CEN (Comité Européen de Normalisation - European Committee for Standardization) in 1990. CEN appointed a Technical Committee (CEN/TC250 "Structural Eurocodes") to establish primarily provisional standards (ENVs) which were transformed into European standards (EN) from 1998 to 2007. Presently, CEN/TC250 has started the revision of the current Eurocodes under Mandate M/515[3] and a new "generation" of the Eurocodes (but based on the same concepts and methods) will be ready for adoption by member states within a few years.

From a technical point of view, Structural Eurocodes are a set of harmonized technical rules for the design of construction works (at room and at elevated temperatures). The National Standards implementing the Eurocodes may be followed by a National Annex. The National Annex may only contain information on those parameters which are left open in the the Eurocodes for national choice, known as the Nationally Determined Parameters (NDPs).

There are three major documents for civil engineering works at European level. First, the REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonized conditions for the marketing of construction

[1] FIP was the « Fédération Internationale de la Précontrainte » (in French) – International Federation of Prestressing.

[2] JCSS: Joint Committee on Structural Safety.

[3]http://ec.europa.eu/growth/tools-atabases/mandates/index.cfm?fuseaction=search.detail&id=523

products and repealing Council Directive 89/106/EEC quoted above. This Regulation defines the following fundamental requirements for construction works:

- Mechanical resistance and stability;
- Safety in case of fire;
- Hygiene health and environment;
- Safety and accessibility in use;
- Protection against noise;
- Energy economy and heat retention;
- Sustainable use of natural resources.

The two other important documents are the DIRECTIVE 2014/24/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on public procurement and repealing Directive 2004/18/EC and the DIRECTIVE 2014/25/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC.

In France, the regulation of 9 March 2011 (CPR) is, of course, directly applicable. It was the basis for the publication of two important documents:

- A prescription dated 23 July 2015 concerning public contracts;
- A decree dated 25 March 2016 concerning public contracts (formerly Public works contract regulation dated 1st of July 2006).

The use of the Eurocodes is compulsory only within the framework of the protection of buildings and other construction works towards earthquakes and within the framework of the protection towards fire. Concerning the French regulation on the protection of structures against earthquakes, the main documents referring to the Code of the Environment, the Code of the Construction and of the House Environment are the following:

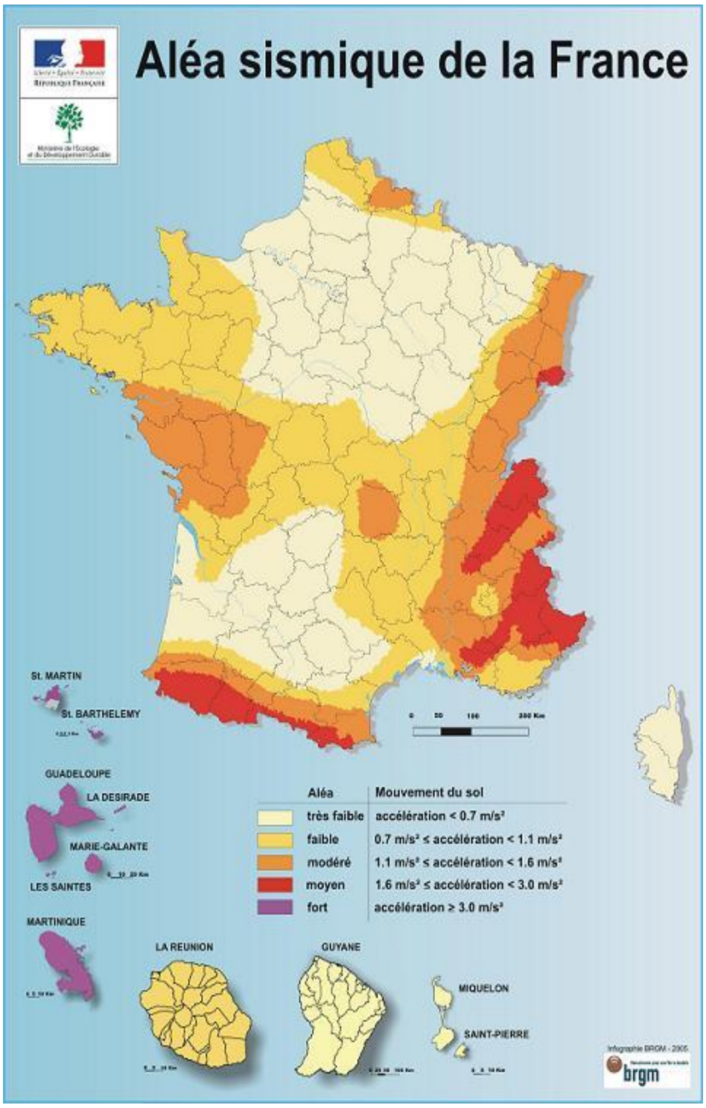
- Decree Nr. 2010-1264 dated 12 October 2010 for buildings of the class «Normal risk», amended by Orders dated 19/07/2011, 25/10/2012, 15/09/2014.
- Decree dated 24/01/2011 giving earthquake-resistant rules for some classified installations, amended by orders 13/09/2013, 19/06/2016, 15/02/201. The class «Normal risk» includes buildings where the seismic risk is limited to their occupants and to their immediate vicinity (4 importance categories).
- Decree dated 26 October 2011 for bridges of the class «Normal risk».
- Decree dated 25 October 2012 amending decree dated 22 October 2010 concerning the design of buildings of the class «Normal risk».
- Eurocode EN 1998 shall be the standard to be used in association with the other Eurocodes.

The seismic zone map of France is established by the relevant National Authorities. The seismic hazard of the French Territory is given in Figure 7.1.

This zone map was established for a return period of earthquakes of 475 years, corresponding to a probability of exceedance of 0,1 for 50 years.

For safety in case of fire concerning construction works, the basic principles are:

- The load bearing capacity of the construction should be assumed for a specific period of time.
- The generation and spread of fire and smoke within the works are limited.
- The spread of fire to nearby construction works is limited.
- The occupants can leave the works or be rescued by other means.
- The safety of rescue teams is taken into consideration.



The values of the nominal acceleration are:

ZONE	a_{gR} (m/s^2)
Zone 1 Very low	0,4
Zone 2 Low	0,7
Zone 3 Moderate	1,1
Zone 4 Medium	1,6
Zone 5 High	3,0

Figure 7.1 Seismic hazard of the French Territory [© Ministry of Roads and Bridges, France]

Eurocodes EN 1991 to EN 1996 and EN 1999 have a Part 1-2 devoted to structural design in case of fire situations, as shown in Figure 7.2.

All Eurocode Parts concerning structural fire design are coordinated by the Horizontal Group Fire (CEN/TC250 HG-Fire).

The two major documents of the French Administration are:

- Order dated 17 August 2016 concerning the prevention of the disasters in the covered warehouses.
- Law Nr. 2018-727 of August 10th, 2018, for a State in the service of a reliable Society.

All calculations refer to the clauses and methods of the Eurocodes.

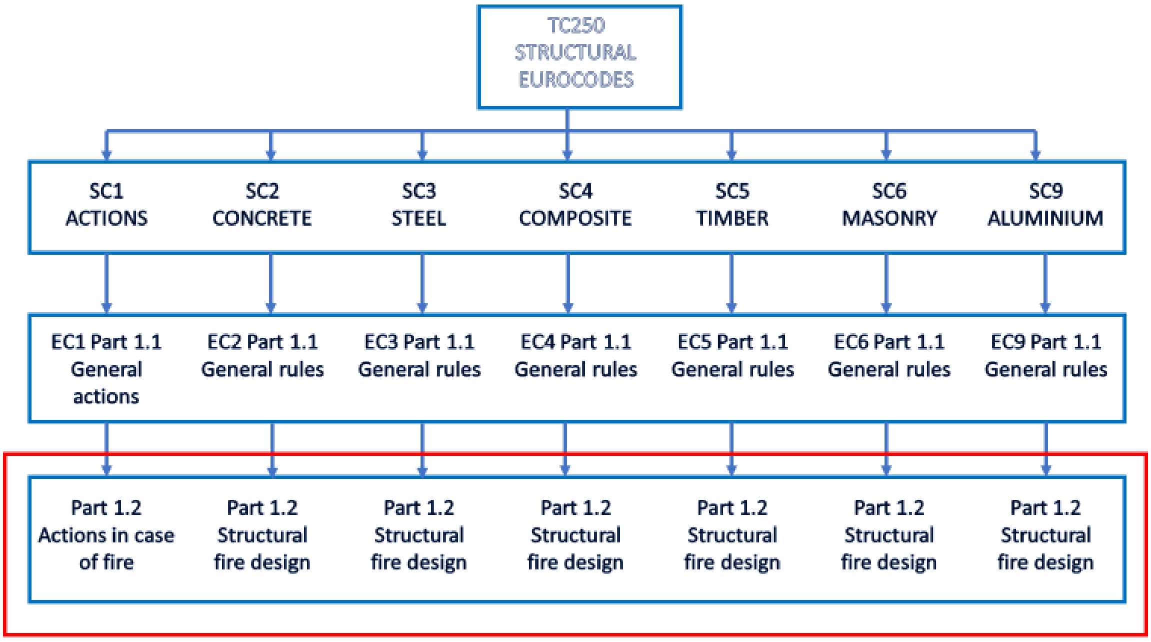


Figure 7.2 The structural Eurocodes and the structural fire design

7.2 Some reflections on the French experience

For designers, the Eurocodes are reference documents. There is now a great number of other types of works than buildings and bridges, in particular subterranean works, interfering with ground and, sometimes, foundations of existing structures. Moreover, the creativity of certain audacious architects does not simplify the task of engineers.

In the design companies, young engineers are in charge to solve very complex problems, without, in many cases, the help of a senior engineer. For that reason, they should have a good knowledge of several Eurocodes. Consequently, the Eurocodes system should be homogeneous (principles, concepts, methods, etc.). The present system is rather homogeneous and the new generation of the Eurocodes will have a higher degree of homogeneity, given that the volume of the National Annexes can be limited.

The photos hereafter (see Figure 7.3 to Figure 7.6) show some examples of civil engineering works needing a high level of expertise in structural design and a good knowledge of the technical reference provided by the Eurocodes.

As a conclusion, a reflection from Dr. Henry Bardsley is quoted hereafter, as sent to the author a few years ago:

> "*Let us remember that the EN Construction Codes are primarily a commonwealth of a vocabulary, a lexicon, memorable mathematical formulae, familiar phrases, models of thought, units of measure, secret symbols, secondarily they are common social values, and only thirdly are they anything to do with being physically correct. Those who read the bible may find this familiar. When I see a colleague in Paris transcribe into French a report on matrices and pretension, for a project on the Rhine, drafted in mandarin-English by a Shanghai colleague based in Stuttgart, I say that the priority is a common lexicon*."

Figure 7.3 Music auditorium on the Seine [photo courtesy of Jean-Armand Calgaro]

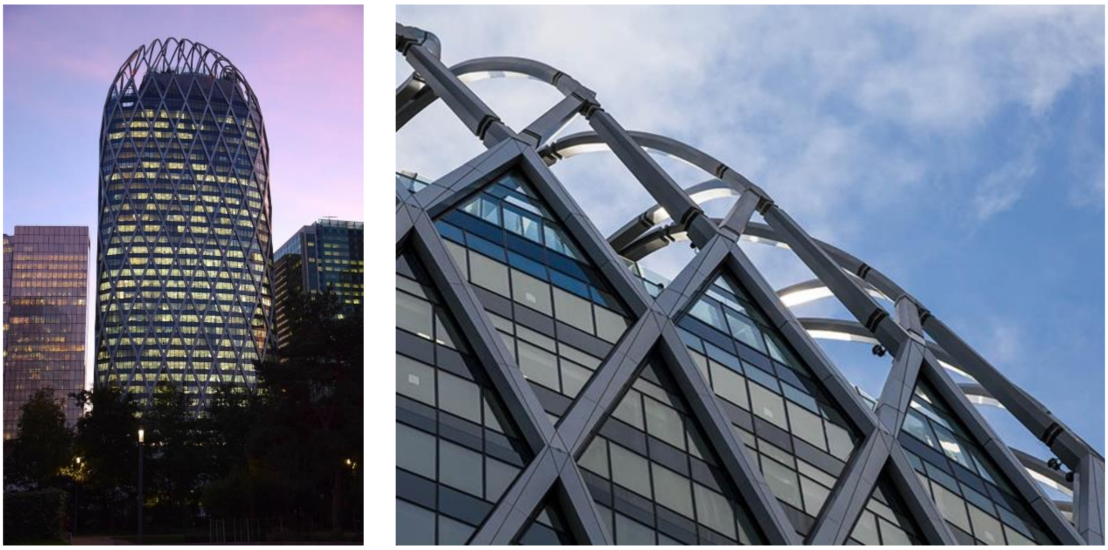


Figure 7.4 D2 Tower in La Défense (near Paris) [© VINCI Construction]

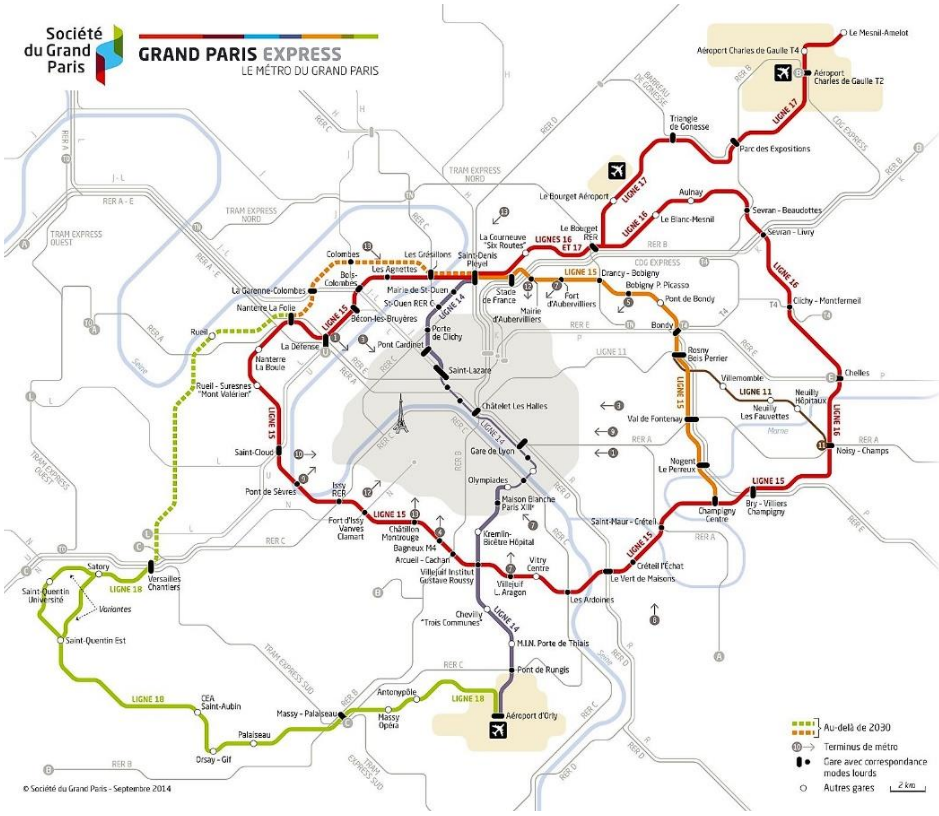


Figure 7.5 Map of the new subway for the Grand Paris, Paris, France [© Society of Grand Paris, source: www.societedugrandparis.fr]

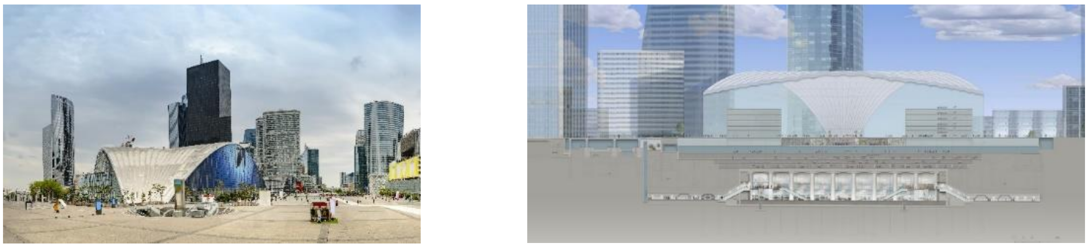


Figure 7.6 The new railway station (Grand Paris) under the car park below the CNIT in La Défense [left: zefart, © Adobe Stock, 2019; right: © VINCI Construction]

CHAPTER 8

THE IMPLEMENTATION OF THE EUROCODES IN THE EU: CASE STUDY - GREECE

Nikolaos MALAKATAS

Chairman of CEN/TC250/SC1 EN 1991

Chairman of the Greek Eurocodes Mirror Committee (ELOT/TE 67)

8 The implementation of the Eurocodes in the EU: Case Study - Greece

8.1 Recent environment for the implementation of the EN Eurocodes

8.1.1 General environment/framework for the implementation of the EN Eurocodes under Mandate M/515

As it is known the EN Eurocodes, following the issuance and publication of corrigenda and amendments, have already been implemented since some years in practically all CEN Member States (MS) and some CEN affiliated and neighboring countries, as well (see also Dimova et al., 2015).

The first conclusions from the Eurocodes application at national level have been essentially expressed with the opportunity of the relevant systematic reviews launched by CEN, few years ago. One of the most important outcome was an expressed willingness for achieving (more) ease of use and for reducing the number of the national choices foreseen (i.e. the Nationally Determined Parameters - NDPs). This aspect reflects also the tendency for more harmonization, in view of promoting universally the Eurocodes and the European construction industry in general.

The ongoing revision of the EN Eurocodes is materialized under Mandate M/515 (EC, 2012) which superseded, as a smooth evolution, the initial Mandate M/466 (EC, 2010). In both documents, key objectives of this development process are declared:

- the encouragement/accompanying of innovation (related to materials and products, construction techniques and research on design methods), ensuring that the Eurocodes reflect and incorporate sustained market developments;
- taking into account new societal demands and needs;
- facilitating the harmonization of national technical initiatives on new topics of interest for the construction sector.

The Structural Eurocodes to be developed under M/515 are deemed to cover at least:

- assessment, re-use and retrofitting of existing structures;
- strengthening of the requirements for robustness;
- improving the practical use for day-to-day calculations (addition in M/515);
- new Eurocode on structural glass;
- incorporation of ISO Standards in the Eurocodes family, such as atmospheric icing of structures and actions from waves and currents on coastal structures.

CEN is requested to provide:

- the development of new standards or new parts of existing standards ("vertical approach");
- the incorporation of new performance requirements and design methods ("horizontal approach");
- the introduction of a more user-friendly approach, in several existing standards ("horizontal approach");
- A technical report on how to adapt the existing Eurocodes and the new Eurocode for structural glass to take into account the relevant impacts of future climate change.

A very important aspect of the further development of the current EN Eurocodes is that their revision was perceived and planned as an "evolution", and not a "revolution".

The Mandate M/515 expectedly is established and financed in the framework of the Framework Partnership Agreements (FPA) 2014-2020 rules. As a result (together with other practical management aspects), there was a need for phasing of the whole contractual work of the various Project Teams (PTs). Namely:

- Phase 1 (25 PTs): Start January 2015 - End June 2018
- Phase 2 (22 PTs): Start January 2017 - End June 2020
- Phase 3 (18 PTs): Start January 2018 - End June 2021
- Phase 4 (8 PTs): Start June 2018 - End June 2021

The sequence scheduled for the delivery of PT drafts has been planned as follows:

- Starting Day (SD) + 16 months: First Draft
- SD + 28 months: Second Draft
- SD + 34 months: Final Draft

Informal commenting periods following each delivery phase are foreseen and favored, in view of detecting major National Standards Bodies (NSBs) concerns as soon as possible, if any, in order to limit/avoid the risk of opposition at the time of formal voting.

It is evident that it is about an ambitious project to be achieved, with very tight time schedules and milestones (deadlines), which needs and has indeed a decent management.

As a result, a lot of pressure is transferred, not only on the PTs but also on the National Eurocodes Mirror Committees who are invited to review a significant number and volume of documents quite frequently and in short periods.

An additional difficulty arises for the NSBs, namely for detecting and supporting available experts to be appointed in the numerous Working Groups.

8.1.2 Greek environment/framework of the further development (revision) of the EN Eurocodes under Mandate M/515

After the Second World War various Codes have been implemented in Greece, mainly for the design of buildings, as well some other civil engineering structures, starting with the "Code of Loading on structures" in 1945. At that time, it was felt that the urgency of the reconstruction of the country practically imposed the adoption of a set of Design Codes from a technically advanced foreign country and the choice has been to implement the relevant German DIN standards. Eventually, this choice compared to other options, e.g. the American standards, codes of practice or technical specifications, also adopted for other engineering fields, such as road design and construction, was due to the fact that most of the Professors in Greek Technical Universities had studied in Germany before the War. In 1959, following a number of disastrous earthquakes, especially in the Ionian islands, the first Paraseismic Code in Greece has been implemented, considered at that time as a rather advanced document, from a scientific and engineering point of view. This Code has been partially modified with additional clauses in 1984, in order to incorporate in between good established and more recent technical knowledge. In 1989, a new Paraseismic Code (known as NEAK in Greek) has been issued, together with a Greek Code for Reinforced Concrete Structures, inspired by the CEB Model Code 1978. Both of them have been revised initially in 2000 and again in 2003.

In the meantime, once the ENV Eurocodes have been published, since 1996, the competent Greek Authorities have adopted their use in the country, for those types of structures not covered by the implemented National Code(s), i.e. essentially for steel, composite steel-concrete and timber structures. At the same time, the accompanying National Application Documents (NAD) have been issued.

As far as types of structures other than buildings where concerned, in particular for bridges, the DIN standards continued to be used followed by their evolution in the form of DIN-Fachberichte (DFB). In addition to them, the competent Greek Authority issued a number of accompanying Guidelines, the most important of which were (MEPPW, 2007):

- Guidelines for the application of DIN-Fachberichte in Greece;
- Guidelines for the paraseismic design of bridges (& seismic isolation).

Once the whole set of the EN Eurocodes was published, the Greek Ministry of Environment, Planning and Public Works proceeded in 2008, in the implementation of the so-called "Provisional Recommendations" (in Greek ΠΡΟΣΥ), in the place of National Annexes not yet officially issued by the Greek National Standards Body (Hellenic Organization for Standardisation - ELOT) at that time (MEPPW, 2008a &MEPPW, 2008b). In fact, the whole project of the Eurocodes implementation, including their translations into Greek, as well as the issuance of the associated National Annexes has been officially accomplished in May 2011.

In the meanwhile, the publication of an important document which was under preparation during some years, the Code for Retrofitting of Structures (in Greek ΚΑΝΕΠΕ), was published as Non-Contradictory-Complementary-Information (NCCI) to EN 1998-3 "*Assessment and retrofitting of buildings*", initially in 2012 (MITN, 2012) and revised in 2013 (MITN, 2013).

8.2 Brief overview of the procedure for the implementation of EN Eurocodes in Greece and last years' evolution in the field of standardization and relevant regulatory activities

The period 2011 – 2013 has practically been a "dormant" (non-active) period and a sort of a break, as far as the activity concerning the Eurocodes was concerned, due to various reasons. In a first place, there was lack of financing, mainly due to the spreading financial and economic crisis in Greece. But the main reason for not implementing the EN Eurocodes Greece was the question of copyright which remained unresolved. The application of a normative document (law, decree, ministerial decision etc.) is mandatory according to the legal tradition of the country and would require the publication of the integral text of the standards in the Official Journal of the Hellenic Republic. In the case of the Eurocodes, such action would jeopardize the rights of ELOT to commercially dispose the documents, unless a financial arrangement could be settled, which had not been the case. As a result, only a non-mandatory use of the EN Eurocodes could be envisaged.

Therefore the "Common Ministerial Decision" DIPAD/372/30-05-2014 (MITN, 2014) had been issued rendering the use of existing national regulatory documents non-mandatory and allowing the use of Eurocodes as an alternative option (which is in principle the preferred option and common practice in the case of Public Procurements). This document implies that:

- the Eurocodes in combination with the relevant National Annexes may be used as regulatory documents for the design of new and the assessment and redesign of existing structures, both for public and private (civil engineering) works;
- pre-existing National Codes/Regulations are no more mandatory;

- the Owner/Authority may choose the framework of regulatory documents for structural design among the two following options: either, the pre-existing national regulatory documents, or, the Eurocodes together with their National Annexes;
- a selective use of clauses from the two regulatory systems is prohibited.

Since 2014, the Eurocodes Mirror Committee ELOT TE 67 "Structural Eurocodes" has been reactivated with Dr Nikolaos Malakatas as Chairman and Mrs Eugenia Gardeli as Secretary (ELOT, 2014). With an additional decision of ELOT, 11 Working Groups (WG) have been established within TC 67 (mirroring the structure of the EN Eurocodes). The Mirror Committee convenes a number of times per year as appropriate, in order to follow up the activities of CEN/TC 250, its Co-ordination Group (CG) and its Sub-Committees (SCs).

The "main thrust" of TC 67, at least as far as comments and replies to questionnaires are concerned, comprise EN 1998 – which is quite understandable, due to the importance of this Eurocode for Greece – and EN 1993 to a lesser extent, as well as issues related to bridge design. In this very moment, a "refreshing" of membership is planned, in order to increase Greece's follow-up of the revision of the EN Eurocodes under M/515. The revision of the climatic actions (snow, wind, thermal) National Annexes is also envisaged with the contribution and support of the Hellenic Meteorological Service[1].

Unfortunately, during the last years there is practically no financing; this is estimated in the order of 20-30 K€/year, essentially for participation of national delegates to meetings, as well as for secretarial /editorial activities, including translations whenever required.

This situation may be partly explained by the priority given by the Government to the revision of 440 Technical Specifications, linked to execution and product standards to be used in the framework of the CPR and the new Greek law 4412/2016 for Public Procurement.

In fact, the financial and economic crisis since 2009, still under way although signs of progressive recovery are now visible, had as direct impact the limitation or even lack of resources during a number of years. It had also as indirect impact a drastic shrinkage of design and consultancy contracts, as well as construction works, which in turn is reflected in a negative way on the need for use of codes/standards and on the priority for their revision. A side effect of this situation was the "expatriation" of the most competitive consulting firms and a significant number of engineers (often at low cost conditions).

8.3 Implementation of EN Eurocodes in Greek practice

Within this context, a positive message is given for the implementation of the EN Eurocodes in practice thanks to the achievements of Greek consultant/engineering companies. Some representative cases performed by two of the most renown Greek design firms, DOMI S.A. and DENCO Structural Engineering P.C., are presented in this section, not as selected publicity, but just as examples of good practice. It is interesting to note that many of them concern works in countries other than Greece. Specifically:

The design of the following projects, shown in Figure 8.1 to Figure 8.4 (courtesy of DOMI S.A.) has been performed by the named Engineering Consultant Company according to the EN Eurocodes.

[1] http://www.emy.gr/emy/en/

Memaliaj Bridge, Albania: Road Bridge with a prestressed box girder and a steel-concrete composite deck, L=123m, S_{max}=76m. Complete design, construction consultancy by DOMI S.A. (Figure 8.1).

Figure 8.1 Memaliaj Bridge, Albania [© DOMI S.A.]

Fier-Tepelene, Albania: Road Bridges with various systems (prestressedor steel girders with in-situ concrete composite slab,L_{max}=167m, S_{max}=40m. Complete design, construction consultancy by DOMI S.A. (Figure 8.2).

Figure 8.2 Bridges Luftinja (left) and Ali Pasha (right) in Fier-Tepelene, Albania [© DOMI S.A.]

Astmoor and Bridgewater Bridge, United Kingdom: Road Bridge, Precast prestressed beams, in-situ reinforced concrete diaphragms and deck slab composing a continuous deck with three branches, L=1018m, S_{max}=41m. Design check (Category-III) by DOMI S.A. (Figure 8.3).

Figure 8.3 Astmoore and Bridgewater Bridge, United Kingdom [© DOMI S.A.]

Karelias Bridge, Greece : Pedestrian Bridge, Steel arch, L=45m. Complete design, construction consultancy by DOMI S.A. (Figure 8.4).

Figure 8.4 Karelias Bidge, Greece [© DOMI S.A.]

Drama - Paranesti, Greece: 11 Railway Bridges, 2 Railway Tunnels, 3 Road Bridges, L_{max}=100m, S_{max}=37m - Final design by DOMI S.A.

Kleidi-Evzoni, Greece: 8 Road Overpasses with reinforced concrete slab, L_{max} =83m, S_{max} =24.5m - Final design by DOMI S.A.

The design of the following projects, shown in Figure 8.5 to Figure 8.23 (courtesy of DENCO Structural Engineering P.C.) has been performed by the named Consultant Engineering Company according to the EN Eurocodes:

PATHE Motorway (Thebes, Ritsona, Atalanti), Greece: Final Design of 3 prestressed concrete overpasses of L_{tot}=70m (2018) by DENCO Structural Engineering P.C. (Figure 8.5).

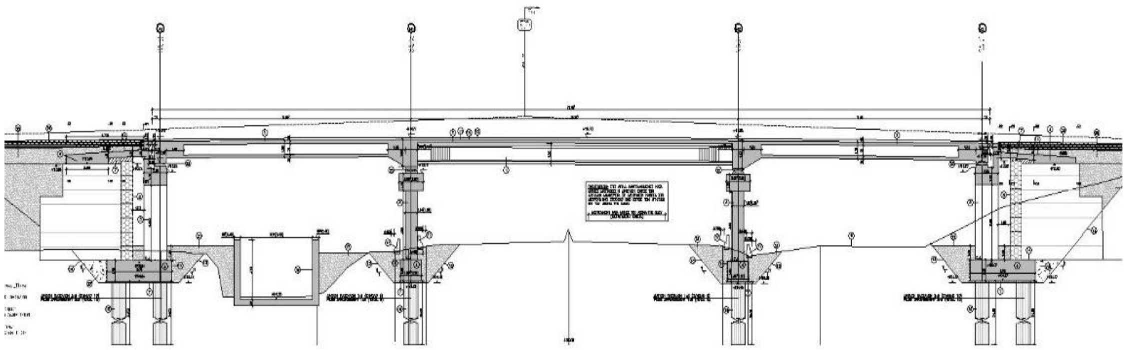


Figure 8.5 Typical Overpass Bridge in PATHE Motorway [© DENCO Structural Engineering P.C.]

Faliron Bay integrated redevelopment, Greece: Design of 2 cut & cover of L_{tot}=300m, alongside parkings, 2 pedestrian bridges and 4 bridges (2012) by DENCO Structural Engineering P.C. (Figure 8.6).

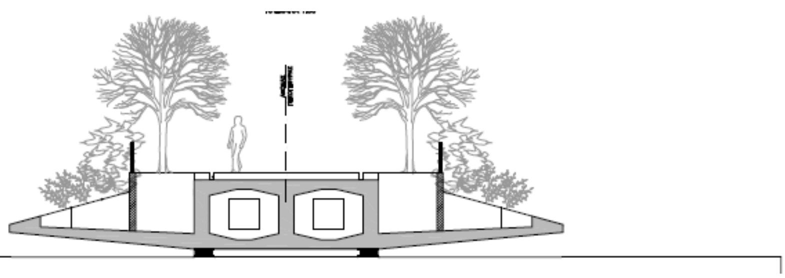


Figure 8.6 Pedestrian Bridge in Faliron Bay, Greece [© DENCO Structural Engineering P.C.]

Nicosia Ring-road, Cyprus: Final Design of 7 bridges with seismic isolation and 17 over- and underpasses (2013-2018) by DENCO Structural Engineering P.C. (Figure 8.7).

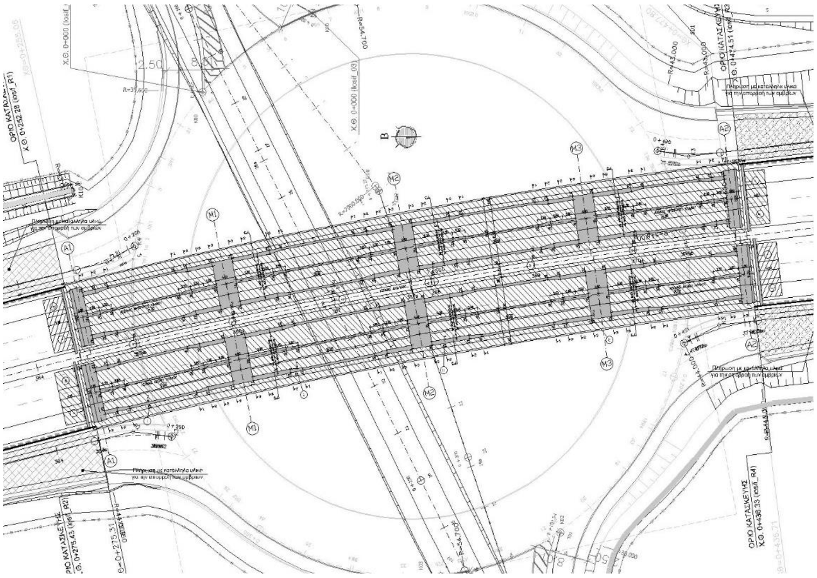


Figure 8.7 Bridge in Nicosia Ring-road, Cyprus [© DENCO Structural Engineering P.C.]

Regional Aegean Airports, Greece: Final Design of the new 8700m^2 terminal of Mytilini airport by DENCO Structural Engineering P.C. (Figure 8.8).

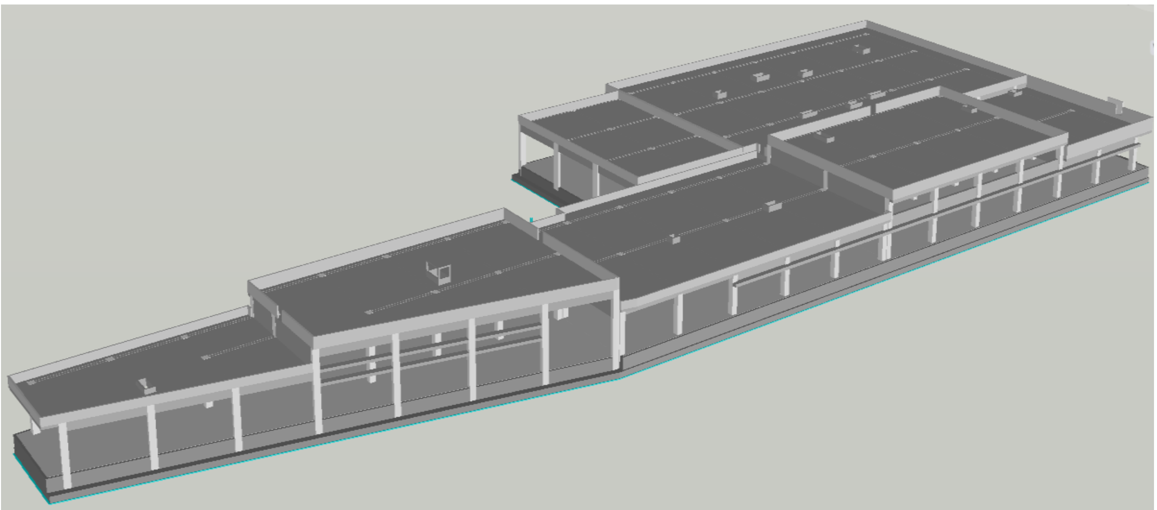


Figure 8.8 Terminal of Mytilini airport, Greece [© DENCO Structural Engineering P.C.]

ELECTRICAL POWER STATION– BESMAYA – PHASE 2, Baghdad, Iraq: Structural Design of major equipment foundations (Gas Turbine – Generator Pedestals, Steam Turbine– Generator Pedestals, involving special vibration analyses) and other foundations and auxiliary structures for the new 1500MW (Units 3 & 4) combined cycle, gas-fired Power Plant, by DENCO Structural Engineering P.C. (2016 – 2018) (Figure 8.9).

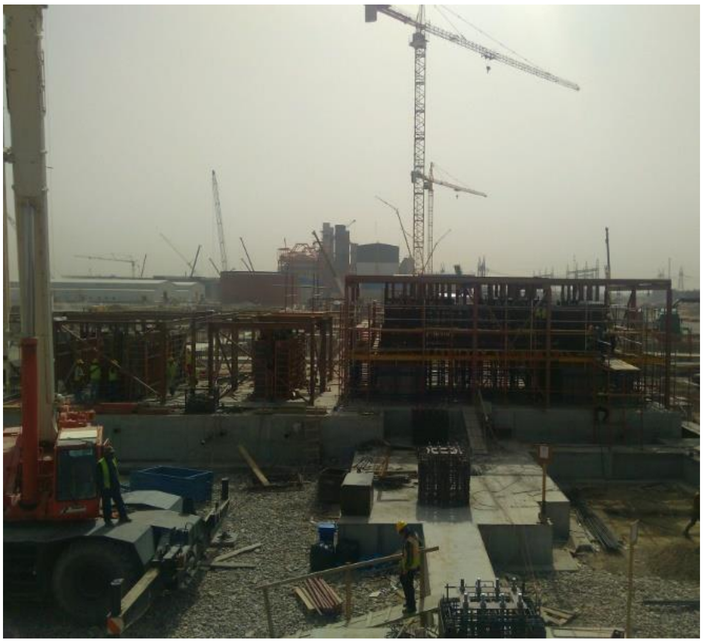


Figure 8.9 Electrical power station – Besmaya – Phase 2, Baghdad, Iraq [© DENCO Structural Engineering P.C.]

HASSI R'MEL I & II OCPP, HassiR'mel, Algeria: Structural Design of major equipment foundations (Gas Turbine – Generator Pedestals, involving special vibration analyses) and other foundations and auxiliary structures for the new368MW (Units 1 & 2) and 590MW (Units 3, 4 & 5) open cycle, gas-fired Power Plant, by DENCO Structural Engineering P.C. (2013 – 2016) (Figure 8.10).

Figure 8.10 HASSI R'MEL I & II OCPP, Hassi R'mel, Algeria [© DENCO Structural Engineering P.C.]

SHAT AL BASRA OCPP,Shat al Basra, Iraq: Structural Design of equipment foundations, concrete buildings and tanks and steel buildings for the new 1250MW open cycle, LDO/gas-fired Power Plant and its First Extension (HFO storage and treatment),by DENCO Structural Engineering P.C. (2012 – 2015) (Figure 8. 11).

Figure 8. 11 SHAT AL BASRA OCPP, Shat al Basra, Iraq [© DENCO Structural Engineering P.C.]

ZARQA PHASE III ADD-ON CCPP, Zarqa, Jordan: Structural Design of major equipment foundations, concrete reservoirs and steel buildings for the new 143MWcombined cycle add-on to Phase III of Zarqa Power Plant, by DENCO Structural Engineering P.C. (2013 – 2014) (Figure 8.12).

Figure 8.12 ZARQA PHASE III ADD-ON CCPP, Zarqa, Jordan [© DENCO Structural Engineering P.C.]

DEIR ALI II CCPP, Deir Ali, Syria: Structural Design of steel and concrete buildings and reservoirs for the new 701MWcombined cycle, gas-fired Unit II at Deir Ali Power Plant, by DENCO Structural Engineering P.C. (2012 – 2014) (Figure 8.13).

Figure 8.13 DEIR ALI II CCPP, Deir Ali, Syria [© DENCO Structural Engineering P.C.]

PTOLEMAIS V SES, Ptolemais, Greece: Structural Design of concrete buildings, piperack & conveyors steel structures and Boiler Erection auxiliary structures, for the new 600MW (Unit 5) lignite-fired Power Plant in Ptolemais, by DENCO Structural Engineering P.C. (2014 – 2018) (Figure 8.14).

Figure 8.14 PTOLEMAIS V SES, Ptolemais, Greece [© DENCO Structural Engineering P.C.]

Aigio Overpass Bridges, Greece: Retrofitting and upgrading of a family of Overpass Bridges at Aigio region, built in 1970 to cross the then new National Road Corinth – Patras. The main deck consisted of 3 span voided-slab prestressed concrete supported on V-shaped columns (functioning as 1-bay frame in transverse direction). Spans: 19,3 + 34,6 + 19,3 m. Total width : 9,65 m. Deck height: 1,00~1,12m (Figure 8.15).

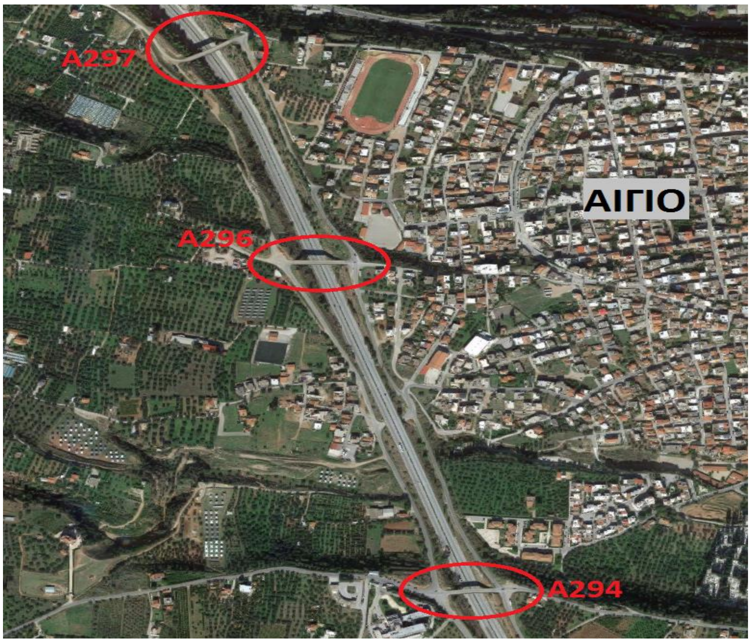


Figure 8.15 Location of Aigio Overpass Bridges, Greece [© DENCO Structural Engineering P.C.]

The retrofit of these Overpasses (as well as of other major bridges of this section of the National Road which has been transformed to Motorway under a Concession Agreement) was aiming to fulfill an increase of service loads x 1.5 (as compared to their design in the late 1960s) and an increase of seismic demands x 5.0. The method of intervention has been optimized in order to achieve the specifications of the project, while the motorway remained partially operational. In particular the extension of the bridge by short (≈6 m) side spans on new abutments allowed the enhancement of the structural behavior, especially vis-à-vis seismic actions in the transverse direction (Figure 8.16). The design constituted the first application in Greece of the provisions of EN 1998-3 for bridges. The main contributors: DENCO Structural Engineering P.C. (Structural Design), SETEC TPI / SALFO S.A. (Independent Engineer), AKTOR S.A. (APION KLEOS J.V.) (Constructor).

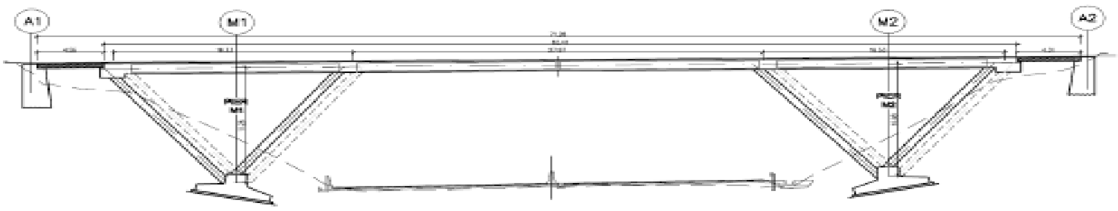


Figure 8.16 Retrofitted typical Aigio Overpass Bridge [© DENCO Structural Engineering P.C.]

More information can been found in Panagiotakos et al. (2018).

Upgrading of Kamares Bridge (south branch), Greece : Several disorders (extensive cracking), mainly in the central span of the existing bridge with 98m length, 15m width and 1.9m height(voided concrete slab) with a prestressed simply supported central span (L=44m) and two reinforced isostatic lateral spans (L=27m) (Figure 8.17). The selected option was the maintenance and retrofitting of the substructure and the substitution of the existing deck by a new one with a phased construction without interruption of the traffic underneath the bridge. The new deck consisted of a central composite steel-concrete span (L=49m) with 2 main beams, monolithically connected with the reinforced concrete lateral spans (voided slab, L ≈ 25m). This type of connection has been applied in Greece for the first time (2016) (Figure 8.18). The bridge is seismically isolated by means of FPS bearings. A view of the bridge after completion is shown in Figure 8.19.

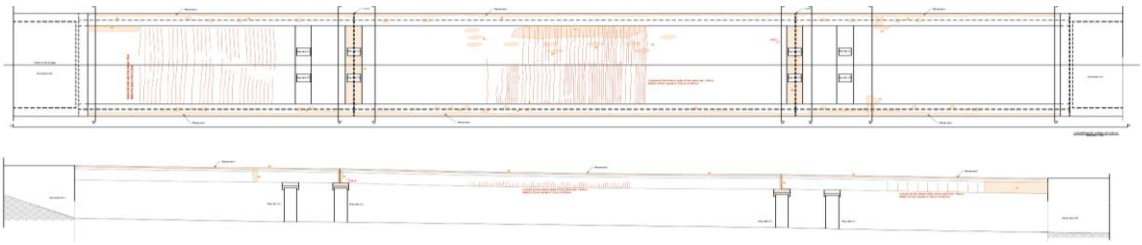


Figure 8.17 Plan and longitudinal view of former Kamares Bridge, Greece [© DENCO Structural Engineering P.C.]

Figure 8.18 Joint between central and lateral spans of the new Kamares Bridge (south branch), before continuity is achieved [© DENCO Structural Engineering P.C.]

Figure 8.19 New Kamares Bridge after completion [© DENCO Structural Engineering P.C.]

More information (in Greek) can been found in Katsaras and Panagiotakos (2017).

3rd LNG Reservoir in Revythousa island, Greece: Final design of the seismic isolation for the 95000m^3 tank including foundation, outer shell and accompanying works by DENCO Structural Engineering P.C. (2010-2018). Other contributions: ADK S.A.-Asprofos Engineering-C&M Engineering SA (Checker), J & P Avax S.A. (Constructor), DESFA S.A. (Owner) (Figure 8.20).

Figure 8.20 LNG plant in Revythousa island, Greece [© DENCO Structural Engineering P.C.]

The structure consists of an internal cryogenic LNG containment steel tank (T=-167^{0}C and p= 29 kPa) and an external concrete tank, prestressed vertically and peripherally, and a reinforced concrete dome (Figure 8.21). It is seismically isolated on 308 triple friction pendulum bearings (FPS) (Figure 8.22).More specifically (Figure 8.23):

- External ring (96 @ 2.61m)
- Internal ring (48 @ 4.36m)
- Central region (orthogonal canvas 4.4m x 4.4m)

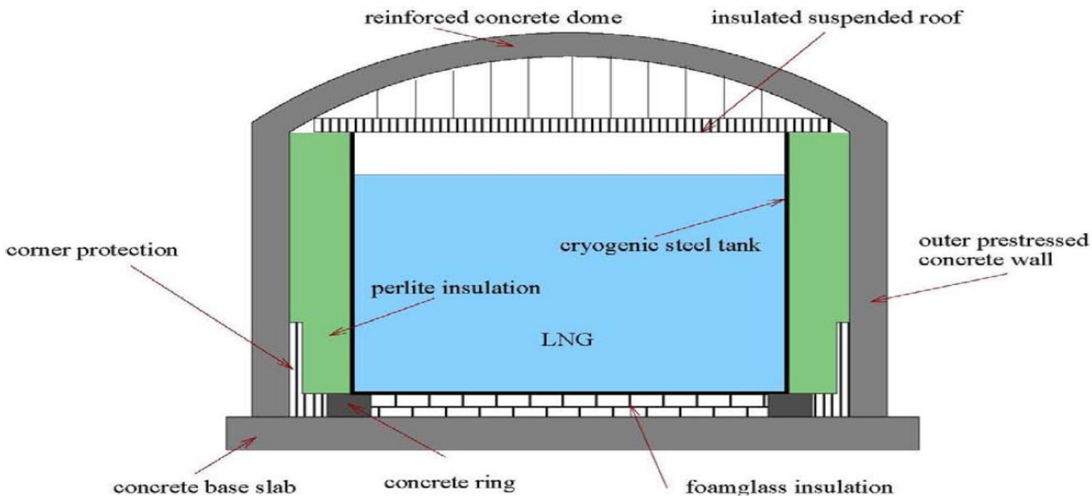


Figure 8.21 Schematic representation of the 3rd LNG Reservoir in Revythousa island, Greece [© DENCO Structural Engineering P.C.]

More information (in Greek) can been found in Katsaras and Panagiotakos (2018).

Figure 8.22 Triple FPS used for the seismic isolation of the 3rd LNG Reservoir in Revythousa island, Greece [© DENCO Structural Engineering P.C.]

Figure 8.23 View of the triple FPS base isolators of the 3rd LNG Reservoir in Revythousa island, Greece, during construction [© DENCO Structural Engineering P.C.]

As already pointed out several other Greek engineering companies and engineers are also using the EN Eurocodes for the design of buildings, bridges and other civil engineering structures.

8.4 Expectations for the future

Despite the moroseness of the international and European environment, it is hoped that financial/economic conditions will be gradually improved. Some shy signs have already appeared this year.

If the building sector is re-launched, it is expected that the application of Eurocodes will be spread, in combination with a set of other regulations/codes (new or revision of existing ones), related to e.g. decreasing energy consumption, improving fire protection etc.

At this moment, the pending translations into Greek of some remaining and new Eurocodes parts (e.g. EN 1992-4) are under way by ELOT. An anticipated targeted restructuring of the Eurocodes Mirror Committee TC 67 together with some – even limited – financing is also expected to improve its efficiency.

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CHAPTER 9

THE IMPLEMENTATION OF THE EUROCODES IN THE EU: CASE STUDY – THE NETHERLANDS

Mark LURVINK

NEN, The Netherlands Standardization Institute

9 The implementation of the Eurocodes in the EU: Case Study - The Netherlands

9.1 Introduction

The Netherlands as a country earned the nickname 'the low countries'. The land is flat and heavily affected by the sea and the rivers Rhine and Meuse meandering into a delta where it is difficult to tell where the river stops and the sea starts. The Dutch have had a love-hate affair with the water since the beginning. The waterways provide excellent opportunities for (international) trade, however flooding forms a serious risk for the inhabitants.

9.2 History of National Standards and Regulations

Communities and cities sprang up in The Netherlands around strategic places. Given that wood was abundantly available in sharp contrast to natural stone, which could only be found in certain area's or had to be shipped from the Eiffel area, it was the main building material for a long time in history. It was not until monks introduced the production of bricks in the late 12th century[1], that it slowly became a construction material for important buildings such as monasteries, churches and defensive works such as castles and city fortifications.

Every city in the country was more or less confined within the boundaries of its city fortifications. Within that area, each had its own set of laws and regulations, including requirements for buildings. Because many buildings were made from flammable material, city fires were not uncommon. At the end of the mediaeval period brick had become a true alternative to wood and thatch work. City governments understood its fire preventing properties and, as an early example of 'building back better', might after a city fire had happened, required that buildings would be erected in brick.

In the 19th century, several important developments took place, which affected urban layout and requirements. The industrial revolution arrived relatively late in the Netherlands, however when it did, combined with already overcrowded cities, it seriously affected the population. Following a cholera epidemic, hitting rich and poor, awareness raised that decent living conditions increased the labour performance of the working class. A report was given to the king[2] in 1835 about the requirements and arrangements of workers homes. This short report can be understood as the start of the Dutch National building legislation.

In addition, the following events impacted urban and technical developments:

- 1824 – start of Nederlandsche Handel-Maatschappij (NHM), the Netherlands Trading Society, to leverage economic activity and encourage the development of national wealth;
- 1839 – first railway from Amsterdam to Haarlem;
- 1842 – TU Delft founded to educate civil engineers;

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[1] See: Blijdenstijn, R. and Stenvert, R. 2000. Bouwstijlen in Nederland 1040-1940, SUN, Nijmegen.

[2] See: Door ene commissie uit het KIVI, Verslag aan den Koning over de vereischten en inrigting van arbeiderswoningen, 1854, Koninklijk Instituut van Ingenieurs (KIvI).

- 1847 - Start of KIvI, society of Dutch engineers;
- 1849 – 'Invention' of reinforced concrete;
- 1864 – Architecture educated at TU Delft;
- 1870 – Industrialization really starts;
- 1874 – Fortification law, new line of national defense against foreign attacks, cities could remove their walls and expand beyond;
- 1902 – Housing act – improve living conditions, main requirements: weatherproof, access to direct sunlight, fresh air, access to drink water and removal of waste water.

Municipalities were required to have a building ordinance, but were free to provide the details as they saw fit. This resulted in regional differences. To overcome these differences a model building ordinance was made available. There were no requirements for Municipalities to incorporate this model ordinance.

- 1912 – publication of Gewapend Beton Voorschriften (GBV) – first standard on reinforced concrete
- 1916 – birth of The Dutch Standardization Institute (NEN) through the Netherlands Trading Society NHM and the society of Dutch engineers KIvI
- 1940 – Start of WWII in the Netherlands, which would end in May 1945
- 1949 – Publication of Dutch building code *N1055 -Technische Grondslagen voor Bouwconstructies*
- 1950 – Rebuilding act
- 1953 – Major flooding resulting from extreme high tide and strong inland storms

Following the 2nd World War there was a lack of housing, funds and building materials. This resulted in yearly plans to allocate the means and resources over the various building sectors and public (civil) works. These yearly plans would later result in Spatial Planning Acts (SPA). The model ordinance was to be expanded and further harmonized, allowing similar designs to be erected in different municipalities, thus simplifying and increasing building production. It would require 15 years for the new model ordinance to become available.

Standards became increasingly important as can be seen from the creation of the International Standards Organization (ISO) in 1947 and the European Standardization Organization (CEN) in 1961. The oil crisis of 1973 created awareness for durability and the need to reduce energy consumption in buildings.

In 1983 the idea was born to deregulate the regional differences through a national building regulation, which became active in 1992. Based upon the model ordinance, the principle was that the laws and regulations would provide the requirements and the standards the means to design and verify against the requirements. Certain requirements, such as resistance to fire and tunnel safety, were not incorporated. In 2003 and 2012 updates of the building regulation addressed these, thus providing a complete set of requirements for constructions, allowing politics to specify the minimum requirements.

Tied to the National Building Regulation was the update of the Dutch standards for structural safety. In 1990 NEN published the NEN 6700-series, a suite of standards which in layout was similar to the Eurocodes, with a separate part for the basis of design, one for actions and separate parts for the materials. In fact, the foreword of NEN 6700 explains that on a European level, work is commencing on the Eurocodes and that it is expected that in the future this series of standards will replace the Dutch suite of standards. This would not happen until the 2012 update of the Building Regulation and the completion of the National Annexes for both bridges and buildings in 2011. An overview of the standards for structural safety in use with the different Building Regulations is given in Table 9. 1 and Table 9.2.

Table 9. 1 Evolution of standards

N1055:1949	NEN 3850:1972	NEN 6700:1990	EN 1990:2005
24 pages Contained: Basis of design Actions Materials	Introduction of semi-probabilistic approach Parts for: Basis of design Actions Materials	Assumed series would be replaced by Eurocodes in due time Parts for: Basis of design Actions Materials Geotechnics Bridges	Parts for: Basis of design Actions Materials Geotechnics Bridges Other structures Seismic design
Did not include concrete, which was in a separate standard	Bridges were available in separate, loosely connected standards	Series was written to comply completely to building regulations in terms and definitions	Developed and published to allow easier exchange of services and goods through Europe

Table 9.2 Overview of the standards for structural safety in use with the different Building Regulations

1902	1992	2012
Municipalities set minimum requirements through local building ordinance, which (may) refer to Standards	National building regulations containing minimum requirements, refers to Standards	See 1992
GBV 1912 N1055:1949 NEN 3850:1972 VB 1974	NEN 6700-series	Eurocodes + National Annexes

9.3 Legal system and connection to standards

The building regulations consist of 3 parts: the Housing Act, the Building Decree and the Ministerial Regulation to the Building Decree[3]. In addition to these, European regulations

[3] A full overview can be found in: Scholten, N.P.M. 2001. Technische en juridische grondslagen van bouwregelgeving - Woningwet en BouwBesluit, Amsterdam

and laws are either incorporated or referenced (the European Tender Directive is incorporated in the Dutch Tender Act, the Construction Product Regulation is mentioned in the Building Decree). An overview is given in Figure 9.1

The Housing act contains high-level definitions and requirements towards:

- Terrain, building, house, owner;
- Erection, existing structures, modification, demolition;
- Local authority;
- Procedure for exceptions;
- Defines that the Safety Check is against the Ultimate Limit State.

Technical provisions are given in the Building decree and Regulation to the Building Decree.

European Commission Recommendation (2003/887/EC), on the implementation and use of the Eurocodes for construction works and structural construction products, recommends that Member States adopt the Eurocodes as a suitable tool for designing construction works. Following discussions with stakeholders, the Dutch government decided to incorporate the Eurocodes in the 2012 Building Decree and move away from the former Dutch Standards (NEN 6700-series). There was no co-existence period.

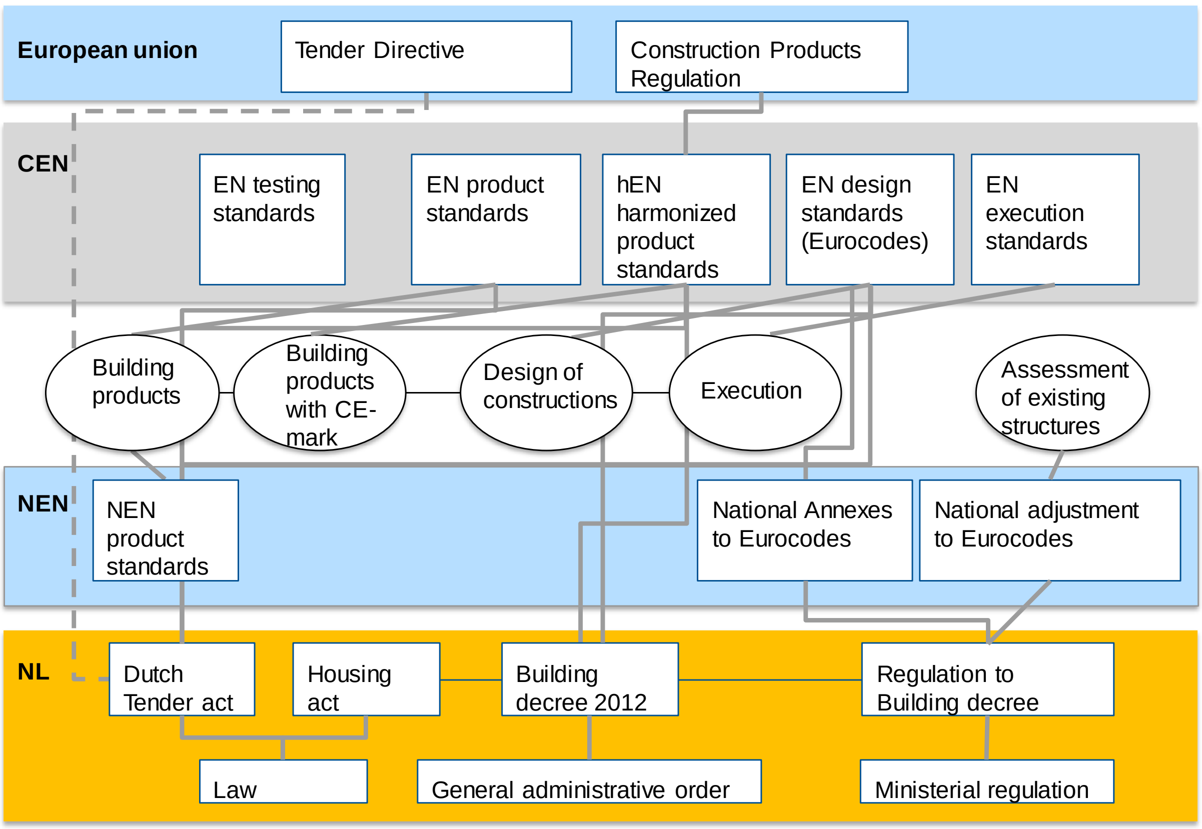


Figure 9.1 Connection between European Laws and Regulations, Dutch Laws, European and Dutch standards[4] [Figure adopted and modified with permission from author, source: https://www.cementonline.nl/artikel/publiekrechtelijke-regelgeving-en-betonconstructies?file=10508.pdf]

[4] Adopted from Scholten, N., S., 2016, Publiekrechtelijke regelgeving en betonconstructies, Cement, 3-2016, pp. 11-15.

The Building Decree provides performance based criteria which should be met before commencing a building activity. Before receiving building permit, approval from local authorities needed, including, structural safety, fire safety and energy consumption amongst others.

The safety level of the structure follows in principle from using the Eurocodes and National Annexes, however Engineers may use other methods, if an equal level of safety can be proven to be achieved (equality principle).

[quote Building Decree 2012]

Section 2.1 General requirements to strength

Article 2.2 Fundamental load combinations

A construction shall not collapse during the design working life as referred to in NEN-EN 1990 under fundamental combinations as referred to in NEN-EN 1990.

Article 2.3 Accidental load combinations

A building construction shall not collapse during the design working life as referred to in NEN-EN 1990 under accidental loads as referred to in NEN-EN 1990, if this leads to the collapse of another construction that is not in the immediate vicinity of that building construction. This is based on the known accidental loads as referred to in NEN-EN 1991.

[…]

Article 2.4 Method of assessment

***1.** 'not collapse' as referenced in articles 2.2 and 2.3 is determined using*

- *NEN-EN 1999 or NEN-EN 1993 when the construction is made from metal as follows from those standards*
- *NEN-EN 1992 or NEN-EN 1996 when the construction is made from stone-like materials as follows from those standards*
- *NEN-EN 1994 when the construction is made from steel-concrete composite as follows from that standard*
- *NEN-EN 1995 when the construction is made from timber as follows from that standard*

[…]

***2.** When another material or method of assessment is used than given in the first clause, 'not collapse' as referenced in articles 2.2 and 2.3 is determined using NEN-EN 1990.*

[…]

[end quote]

The Ministerial Regulation to the Building Decree provides, amongst other provisions, the actual standards, which should be used.

[quote Ministerial Regulation to the Building Decree]

Section 1

Article 1.2 NEN

> *Where reference is made to a standard, the active standard is given in Annex I for NEN standards and Annex II for NEN-EN standards*
>
> *[…]*

[end quote]

Forty-eight individual Eurocode parts and their National Annexes are given in Annex II.

9.4 Adopting the Eurocodes

The Netherlands have taken a five step approach to implementing the Eurocodes:

1. Translation;
2. Calibration against original situation;
3. Development of National Annex;
4. Publication & promotion;
5. Incorporation.

The translation was performed together with the Flemish members of the Belgian Standardization Institute. A list with words for translation were drafted. One country would provide the first translation, the other would verify. Both standardization communities had to approve the final translation.

It was obvious from the start that a calibration exercise was required. Some 15-20 representative buildings and about 10 representative bridges were 'designed' according to the existing standards and the Eurocodes, resulting in recommendations for the National Annexes.

The National Annex was developed with input from the calibration studies, scientific developments. Additionally, stakeholders were considered and the standardization process was followed to conclude to the final text for the National Annexes.

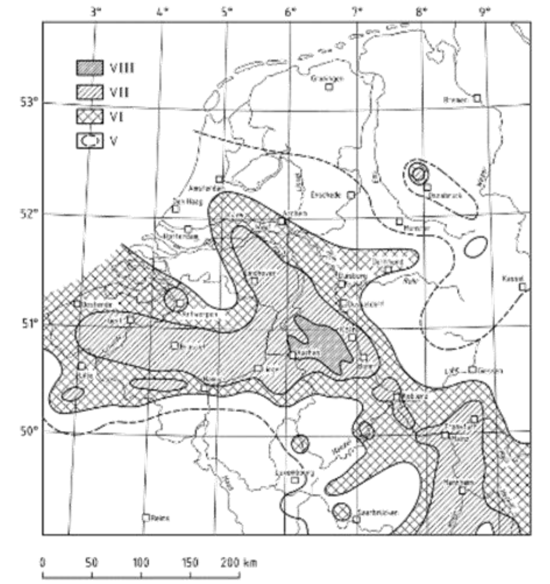
Publication commenced and promotion was undertaken together with partners: branch organizations, engineering associations, research institutes, universities, government and others.

Incorporation into daily work practice did not commence until the very last moment. People wait before they change to a new system. Legislation was a driving force in The Netherlands.

9.5 Earthquakes

Within The Netherlands seismicity is, in most cases, not considered for structural safety. The Building Regulation does not require seismicity to be taken into account when erecting construction works, despite the 1992 earthquake in Roermond which resulted in damages to buildings and levy systems. Figure 9.2 shows the tectonic seismic area's in The Netherlands.

In contrast to tectonic earthquakes, since 2013 induced earthquakes resulting from mining operations (natural gas extraction) in the most North-Eastern province (Groningen) became more prominent when an earthquake in Huizinge had an unexpectedly high magnitude. The gas was used to heat buildings, to cook and as an energy supply for industry. Given that collapse of the buildings in the area was considered a serious risk for the inhabitants of the area, this led to the creation of a Dutch guideline for the assessment of structural safety for buildings[5]. The guideline was based upon EN 1998, parts -1, -3 and -5. Production has been reduced from 42 billion cubic meters (bcm) to 20 bcm and is expected to stop completely in 2030, resulting in significant reductions of the hazard (first studies in 2015 assumed peak ground accelerations of up to 0,4 g).



Figuur NB.4 — Aardbevingsgevoelige gebieden in Nederland en de omliggende gebieden

Tabel NB.6 — Horizontale versnellingen en optredende verschijnselen tijdens aardbevingen

Intensiteit	Omschrijving	Versnelling m/s²
VIII	Vernielend; paniek; algemeen schade aan gebouwen; zwakke bouwwerken gedeeltelijk vernield	2
VII	Zeer sterk; schade aan vele gebouwen; schoorstenen breken af; golven in vijvers; kerkklokken geven geluid	1
VI	Sterk; schrikreacties; voorwerpen in huis vallen om; bomen bewegen; weinig-solide huizen worden beschadigd	0,5
V	Vrij sterk; algemeen gevoeld; opgehangen voorwerpen slingeren; klokken blijven stilstaan	0,2
IV	Matig; door velen gevoeld; trilling als van zwaar verkeer; rammelen van ramen en deuren	0,1
III	Licht; door enkele personen gevoeld; trilling als van voorbijgaand verkeer	0,05
II	Zeer licht; slechts onder gunstige omstandigheden gevoeld	0,02
I	Alleen door seismografen geregistreerd	0,01

Figure 9.2 Seismic area's in the Netherlands (from: NEN-EN 1991-1-7+C1/NB: 2011) [© NEN]

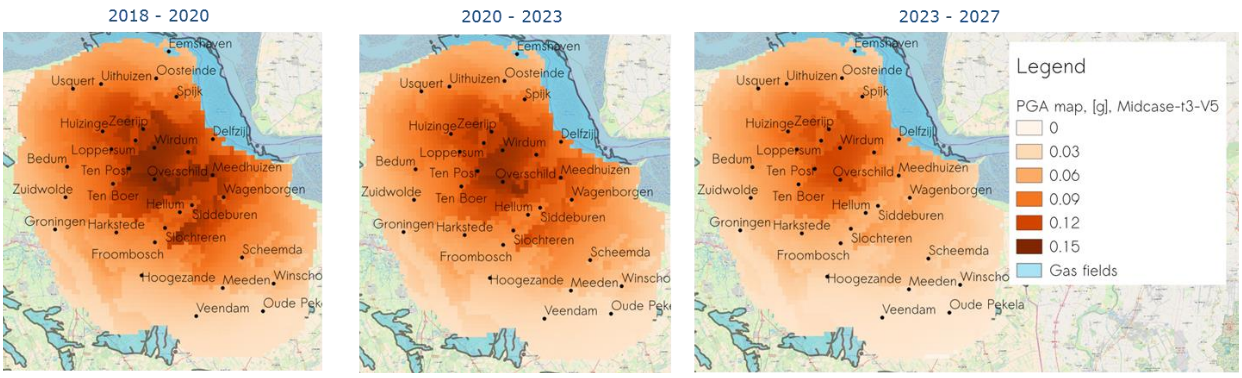


Figure 9.3 Peak ground accelerations for average winter scenario at 475 years return period from induced Earthquakes)
[© KNMI, source: https://cdn.knmi.nl/system/readmore_links/files/000/000/996/original/KNMI_rapport_Over_de_gevolgen_van_afbouw_gaswinning_Groningen_voor_veiligheidsrisico's_en_versterkingsopgave.pdf?1530272074, June 2018]

[5] See also: Cobra 2016: Gas Extraction and Necessary Earthquake Regulations, Part 2.

The buildings in the area are often unreinforced masonry buildings with cavity walls. They have never been designed for earthquakes. Often the leaves of the cavity walls are only 10 cm in depth. Therefore, EN 1998 doesn't fit this particular situation for retrofitting. However, the standards were a great contributor to get 'up-and-running'.

9.6 Lessons learned

There were 5 simple lessons learned while The Netherlands were preparing the National Annexes to the Eurocodes and implementing them in the national legislation:

1. No code is perfect;
2. You can't satisfy everyone;
3. The importance of maintenance of codes (National Annexes) is easily underestimated;
4. Clarity for assessment of and requirements for existing structures when changing design codes is important;
5. Existing Eurocode very helpful to get 'up-and-running' quickly when dealing with new design situations.

9.7 Future developments

In respect to structural safety, within the Dutch standardization committees the main items under discussion are:

- Adoption of 2nd generation of EN Eurocodes;
- Further national standards for existing structures (materials);
- Quality assurance affecting standards and regulations.

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CHAPTER 10

DESIGNERS' EXPERIENCE ON USING THE EUROCODES IN EUROPE AND THIRD COUNTRIES

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10 Designers' experience on using the Eurocodes in Europe and third countries

10.1 Introduction

The present chapter aims to illustrate and critically discuss application of the Eurocodes in design practice, with special emphasis on bridge design.

In the first part, some background information is given about definition of relevant traffic load models.

In the second part two typical, but relevant design case are illustrated, concerning a three span continuous box girder steel bridge with orthotropic deck and a simply supported prestressed concrete bridge with an open cross section.

In choosing the examples, it has been particularly considered that designers need to face common practical cases, characterising the everyday design of bridges. Anyhow, the case studies examples intend also to show that Eurocodes are extremely flexible and suitable to cover all practical needs with different degree of complexity, according to the refinement required by the specific design and project.

10.2 Background of traffic load models for road bridges' design

In modern codes for bridge design, traffic load models for static assessments are given in such a way to reproduce characteristic effects induced by the real traffic.

In Eurocode *EN1991-2 Traffic loads on bridges,* the characteristic effects have been defined as the effects characterized by a probability of exceedance of around 0,1% on annual basis, nearly equivalent to 1000 years return period, induced by a suitable reference traffic.

The reference traffic was selected among European traffic data recorded during two large measurement campaigns performed on European motorways in the years 1980-1990.

The methods used to derive the static and fatigue load models have been widely discussed in several papers, also referring to some relevant case studies (Boussida, 2012; Bruls et al., 1996a; Bruls et al., 1996b; Calgaro et al., 2010; Caramelli and Croce, 2000; Croce, 1996; Croce, 2002; Croce et al., 1997; Croce and Salvatore, 1998; Croce and Salvatore, 2001; Croce and Sanpaolesi, 1991; Croce et al., 1991; Croce and Sanpaolesi, 2005; Sedlacek et al., 1991)

From the measurements, it was observed that the most severe traffic loads in Europe evolved in a very straightforward way during the 1980's. In fact, the percentage of articulated lorries increased up despite a strong reduction in the less commercially profitable trailer trucks. This was in conjunction with a contraction of the number of lighter lorries, increasingly devoted to serve local routes, while due to a better and more rational management of the lorry fleets, the number of empty lorry passages was reduced or limited to the tractor unit only (in case of articulated lorries), so raising the mean of the total loads. All these trends, especially in terms of long distance traffic composition, were well represented in the traffic recorded in France, on the motorway A6 Paris-Lyon near Auxerre, which was chosen as the main reference traffic for the continental Europe.

The analysis of the available European traffic data showed that:

- The mean values of axle-loads and total weight of heavy vehicles depend on traffic type (long distance, medium distance or local traffic) and they are generally very scattered, while daily maxima are much less sensitive to the traffic typology and they vary between 130 and 210 kN for single axles, between 240 and 340 kN for two axles in tandem, between 220 and 390 kN for three axles in tridem, and between 400 and 650 kN for total weight, as it results from Figure 10.1, where the frequency histograms of the total lorry weight recorded in Auxerre is compared with the one recorded in Ireland, on the motorway M4;
- the statistical distribution of the axle-load is generally unimodal, while the statistical distribution of the total weight is bimodal, with a first mode around 150 kN and a second mode around 400 kN;
- daily maxima of axle-loads as well as total weight of lorries largely exceed legal maxima;
- inter-axle distance distribution results trimodal, with a first mode, corresponding to the usual inter-axle for tandem and tridem axles, located around 1.30 m and little scattered, a second mode, typical of the tractors of articulated lorries, located around 3.20 m and again little scattered, and the third one, located around 5.40 m, much more dispersed;
- long distance continental Europe traffic data are homogeneous enough.

Moreover, measurements recently made confirm that even the actual traffic is very well matched by Auxerre traffic, so that further adjustments are not necessary.

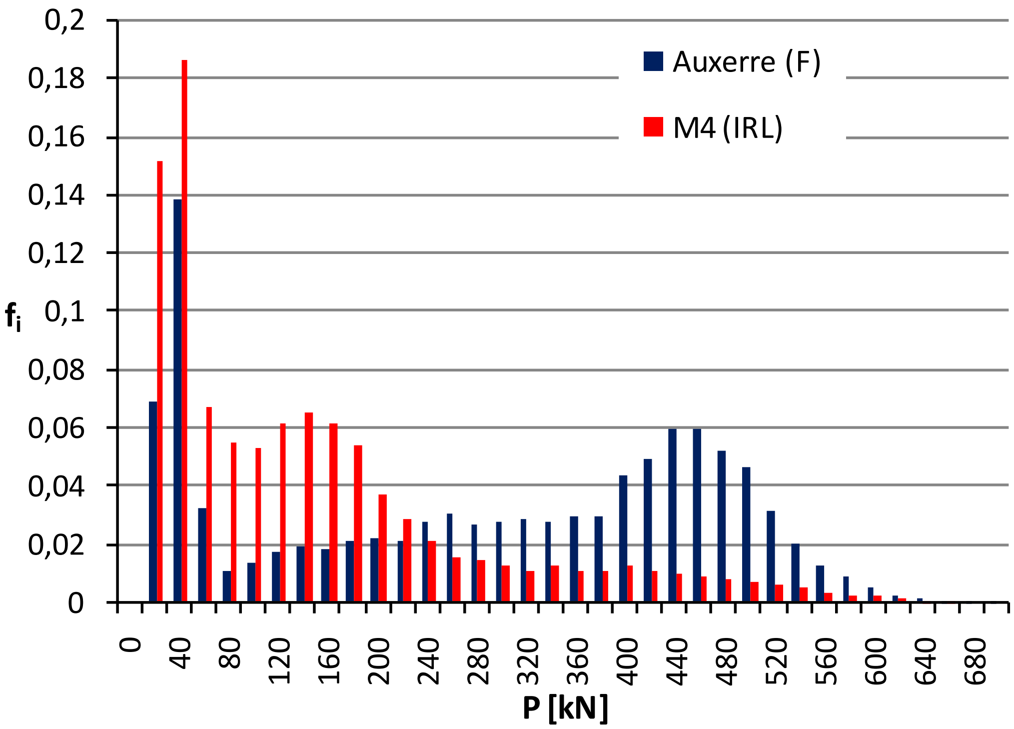

Figure 10.1 Frequency histograms of the total lorry loads in Auxerre and in M4 motorway (adapted from Jacob et al., 2002)

The traffic load models given in *EN1991-2:2003* are the results of a proper calibration performed assuming that a traffic load model in a modern bridge code:

- should be easy to use;
- should be applicable independently on the bridge scheme and on the span length;
- should be able to reproduce as accurately as possible the target values, covering all the possible flowing and congested traffic scenarios, that can occur during the bridge design life;
- should include dynamic magnifications effects in the load values;
- should allow to easily combine local and global effects;
- should be unambiguous, covering all the cases that could occur in the design practice.

10.3 Example of design of an orthotropic steel deck bridge

The first example refers to a three span continuous beam box girder steel bridge, located in an extra-urban area. The three spans are 120 m each, for a total length of 360 m (Figure 10.2).

The carriageway, 10,50 m wide, is supported by an orthotropic steel deck (Figure 10.3), with closed stiffeners. The design calls for two lateral walkways, each 1,50 m in width, separated from the roadway by 90 mm high kerbs. The distance between the bridge intrados and the ground is 20,0 m.

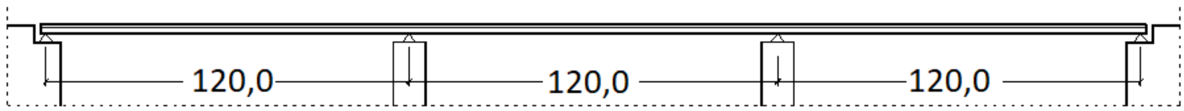

Figure 10.2 Static scheme of the box girder

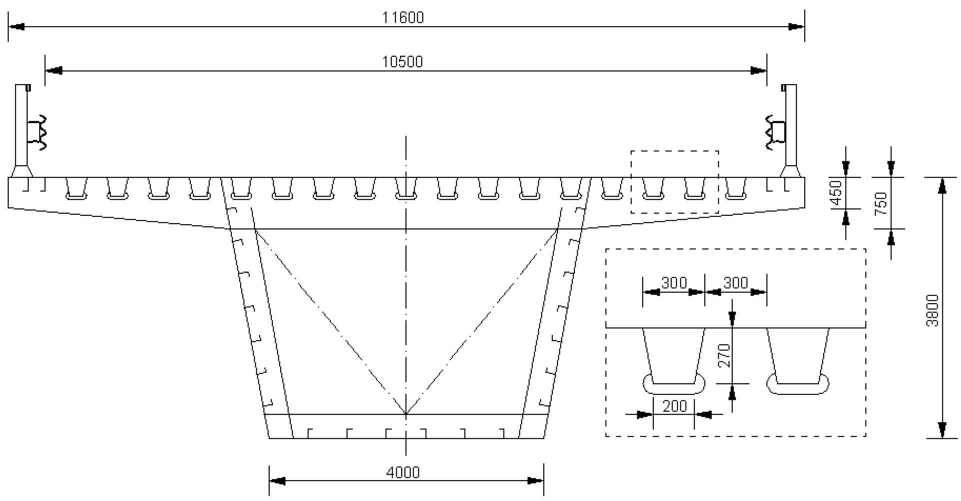

Figure 10.3 Cross section of the bridge

The deck plate is 14 mm thick, the trapezoidal ribs are 6 mm thick and the web of the box girder are 16 mm. The area of the cross section is A=0,407 m^2; the distance of the centre of mass from the deck extrados is 1,268 m and the moment of inertia is J_x=0.945 m^4.

10.3.1 Definition of loads

10.3.1.1 Structural self-weight

Assuming a specific weight of the steel γ =78,5 kN/m^3, the weight of the orthotropic deck is g = $A_b\,\gamma$ = 0,407 m^2 x 78,5 kN/m^3 = 31,949 kN/m

10.3.1.2 Dead loads

The dead loads are those due to the roadway surface, the safety barriers and the walkways. It is a reasonable approximation to consider these loads "globally", as distributed per unit surface, by "spreading out" the effects of the safety barriers, so that the dead load is g_p=2,2 kN/m^2, corresponding to g_p= $g_p \cdot$10,5 m=23,1 kN/m.

10.3.1.3 Traffic loads

According to *EN 1991-2* the roadway width, w, and number of conventional lanes are calculated. The value of the roadway width, w, depends, first of all, on whether the walkways are isolated from vehicular traffic or not. In the case at hand, the walkways are separated from the roadway by 90 mm-high kerbs, so that, according the provisions of *EN 1991-2*, they are potentially accessible to the transit of vehicles so that the width, w, is the net distance between the two outer safety barriers: w=10,50 m.

As w>6,0 m, the number of conventional lanes of 3,0 m wide each is given by:

$$n_l = \mathrm{Int}\left[\frac{w}{3}\right] = \mathrm{Int}\left[\frac{10{,}50}{3}\right] = 3 \qquad (10.1)$$

and the residual area left is 1,50 m (see Figure 10.4)

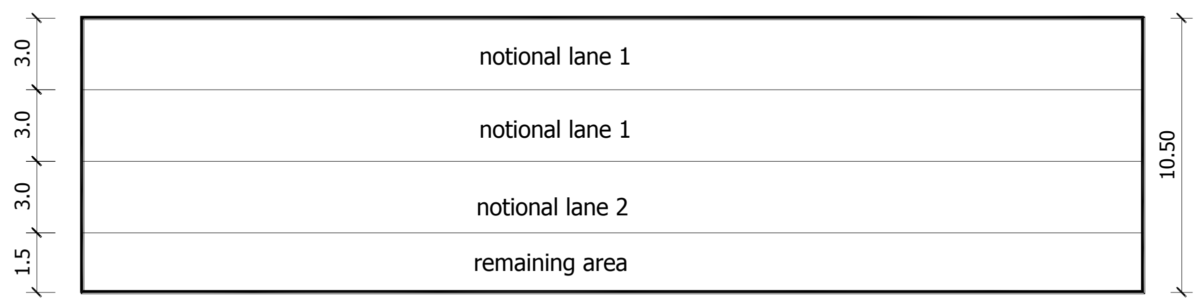

Figure 10.4 Notional subdivison of the carriageway

For the assessment of the cross sections only Load model LM1 of *EN1991-2* is relevant. Crowd loading (LM4) is not accounted for, as the bridge is in an extra-urban area, nor does Load model LM3, which interprets the transit of special vehicles on the bridge. In reality, load models LM4 and LM3 need to be applied only when expressly required.

Load model LM1 provides concentrated loads represented by two axles in tandem, each one weighing Q_k, on each conventional lane (each axle represented by a load Q_k) plus an uniformly distributed load q_k, as illustrated in Table 10.1 that shows the values of these loads for the three conventional lanes and the residual area, calculated including the dynamic amplification coefficient.

Table 10.1 LM1 traffic loads

Conventional lane nr	Q_k [kN]	q_k [kN/m^2]
Lane 1	300	9,0
Lane 2	200	2,5
Lane 3	100	2,5
Residual area	0	2,5

When seeking a determined effect on the bridge, load model LM1 must obviously be arranged in the less favourable position, both transversally and longitudinally. Anyhow, a single lane cannot hold more than one tandem, which, if present should be considered in full, that is, with all four wheels.

By way of example, one possible arrangement of the LM1 on the carriageway to maximize torque for extreme bending moment is represented in Figure 10.5, while to maximize torque only lanes nr. 1 and 2 need to be considered.

10.3.1.4 Wind action

According to *EN1991-1-4:2005*, wind actions can be considered decomposed in three components: one eccentric vertical component and two horizontal components, parallel and orthogonal to the bridge's longitudinal axis.

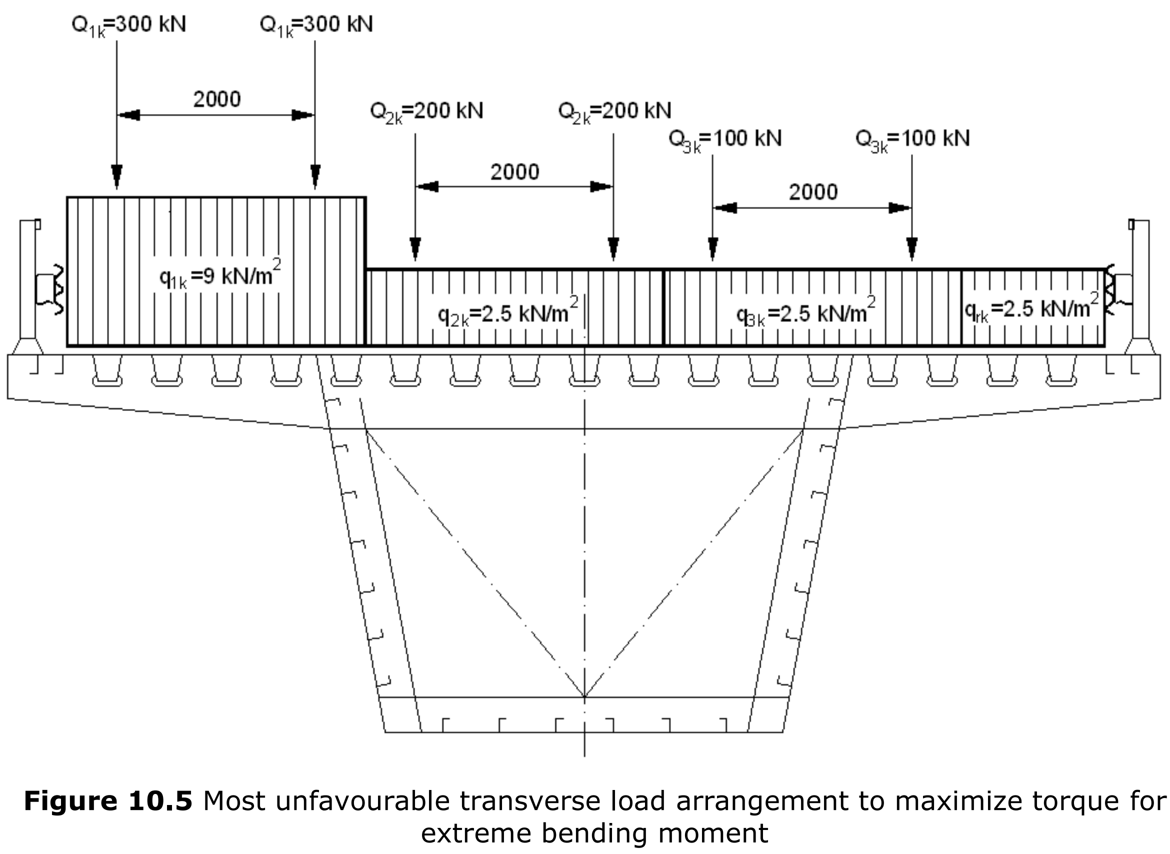

Figure 10.5 Most unfavourable transverse load arrangement to maximize torque for extreme bending moment

The equivalent pressure exerted by the wind is given by:

$$q_p(z_e) = c_e(z_e)\frac{\rho}{2}v_b^2 \tag{10.2}$$

where ρ is the air density, which can be assumed to be 1.25 kg/m^3, v_b is the base wind velocity, c_e is the so-called exposure coefficient, calculated at the reference altitude, z_e, and defined as:

$$c_e(z_e) = c_r^2(z_e)c_0^2(z_e)[1+7I_v(z_e)] \tag{10.3}$$

which also contains the roughness coefficient c_r, the topography factor c_0 and the turbulence intensity I_v. The topography factor, introduced in order to account for any significant local variations in the site's topography, is usually 1,0, while I_v and c_r, instead, are defined by the following relations:

$$I_v(z_e) = \begin{cases} \dfrac{k_I}{c_0(z_e)\ln\left(\dfrac{z}{z_0}\right)} & if\ z_{\min} < z \\ I_v(z_{\min}) & if\ z_{\min} \geq z \end{cases} \tag{10.4}$$

$$c_r(z_e) = \begin{cases} k_r(z_e)\ln\left(\dfrac{z}{z_0}\right) & if\ z_{\min} < z \\ c_r(z_{\min}) & if\ z_{\min} \geq z \end{cases} \tag{10.5}$$

where k_I is a turbulence factor, usually set to one, k_r, z_0 and $z_{\min}$ depend on the site's exposure category. In the present case the bridge is located in an extra-urban area and the terrain can be classified in category II (that is, a setting characterised by little vegetation and isolated obstacles), for which z_0=0,050 m, $z_{\min}$=2,0 m, k_r=0,19. The reference height z_e can be assumed as the height of the midline of the bridge's profile over the ground (Figure 10.6): in the present case, as the intrados of the bridge is 20.0 m above the ground, it results z_e=20,0 m+(3,80/2) m=21,90 m.

As $z_{\min} < z_e$, it results:

$$I_v(z_e) = \frac{1}{1{,}0\ln\left(\dfrac{21{,}9}{0{,}05}\right)} = 0{,}164; \quad c_r(z_e) = 0{,}19\ln\left(\frac{21{,}9}{0{,}05}\right) = 1{,}156\,; \tag{10.6}$$

$$c_e(z_e) = 1{,}156^2\ 1{,}0^2[1+7\cdot 0{,}164] = 2{,}869; \tag{10.7}$$

and, assuming a basic wind velocity, v_b=27 m/s, the equivalent pressure results:

$$q_e(z_e) = 2{,}869\cdot\frac{1{,}25}{2}\cdot 27{,}0^2 = 1307\ N/m^2 = 1{,}307\ kN/m^2. \tag{10.8}$$

Indicating with 'x' indicates the horizontal direction orthogonal to the bridge's axis, the transverse force $F_{w,x}$ acting on the bridge is given by:

$$F_{w,x} = q_p(z_e)\cdot C_{f,x}\cdot A_{ref,x}. \tag{10.9}$$

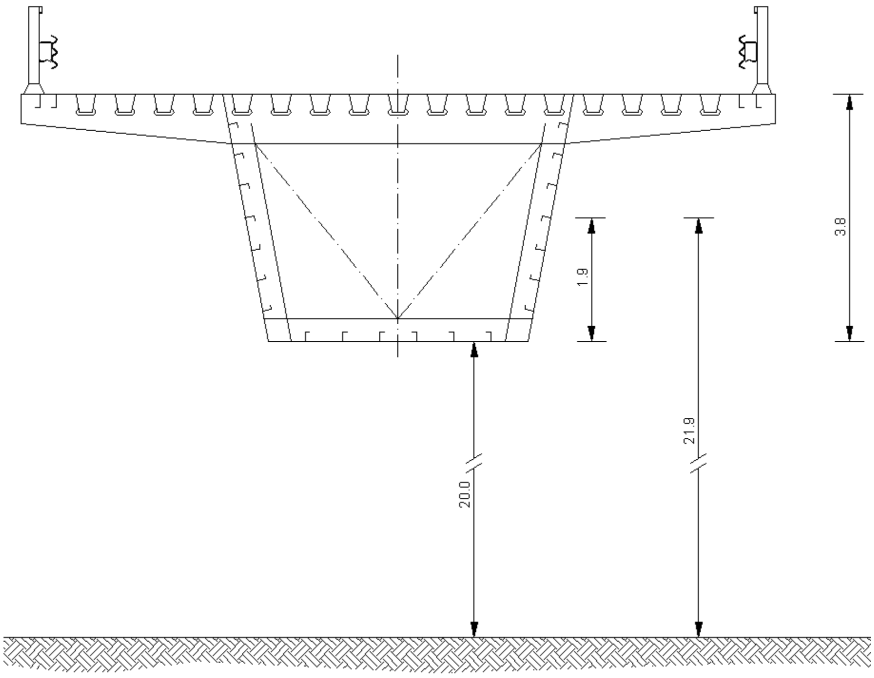

Figure 10.6 Evaluation of reference height z_e

where $A_{ref,x}$ is the longitudinal area exposed to the wind. For unloaded bridge $A_{ref,x}$ is evaluated considering the height of the cross section plus the height of each solid parapet or solid safety barrier and/or the height of conventional strips representing open parapets or open safety barrier (see Figure 10. 7 and Table 10.2).

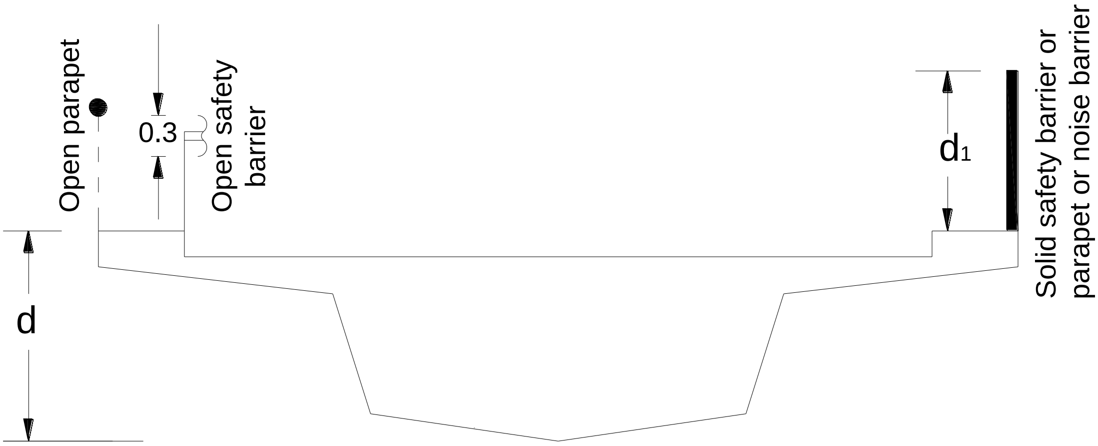

Figure 10. 7 Evaluation of conventional height of $A_{ref,x}$ (unloaded bridge)

The coefficient $C_{f,x}$ is a function of the ratio of the deck's height to its width:

$$C_{f,x} = \min\left(2{,}4; \max\left(2{,}5 - 0{,}3\ \frac{b}{d_{tot}}; 1{,}3\right)\right). \quad (10.10)$$

Considering the presence of the two safety barriers, we have the ratio b/d_{tot}=(11,60 m)/(4,40 m)=2,636, to which corresponds the value of $C_{f,x}$=1,709.

Table 10.2 Evaluation of height of parapets and safety barriers

Road restraint systems and shields	On one side	On both sides
Open parapet or open safety barrier	d+0.3 m	d+0.6 m
Solid parapet or solid safety barrier	$d+d_1$	$d+2\ d_1$
Open parapet and open safety barrier	d+0.6 m	d+1.2 m

As the lateral walls of the box girder are inclined of an angle $\alpha \approx 11°$, $C_{f,x}$ can be reduced by 0,5% α=5,5%. In conclusion, for the unloaded bridge, it results $C_{f,x}$=1,623 and $F_{w,x}$=9,34 kN/m (Figure 10.8).

For loaded bridge, the transverse wind action is evaluated assuming an equivalent height of the lorries equal to 2,0 m, according to EN1991-2 (3,0 m for the Italian NAD), and assuming a reduced wind pressure (Figure 10.9).

$$q_p^*(z_e) = \min\left(0{,}6\ q_p(z_e);\ q_p(z_e, 23\ m/s)\right) \tag{10.11}$$

being 23 m/s the maximum wind velocity compatible with normal traffic flow in absence of wind shield.

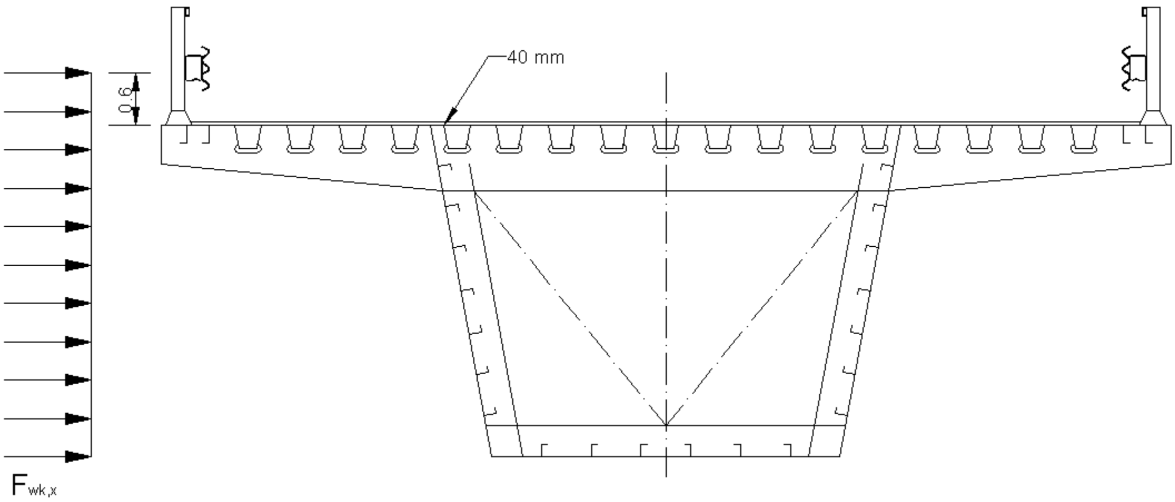

Figure 10.8 Transverse wind force (unloaded bridge)

Therefore, for loaded bridge, it results d_{tot}=5,8 m (d_{tot}=6,8 m for the Italian NAD); consequently, from

$$C_{f,x} = \min\left(2{,}4; \max\left(2{,}5 - 0{,}3\ \frac{b}{d_{tot}}; 1{,}0\right)\right), \tag{10.12}$$

it results $C_{f,x}$=1,9 ($C_{f,x}$=1,99) from which $F_{w,x}$=8,21 kN/m ($F_{w,x}$=10,04 kN/m).

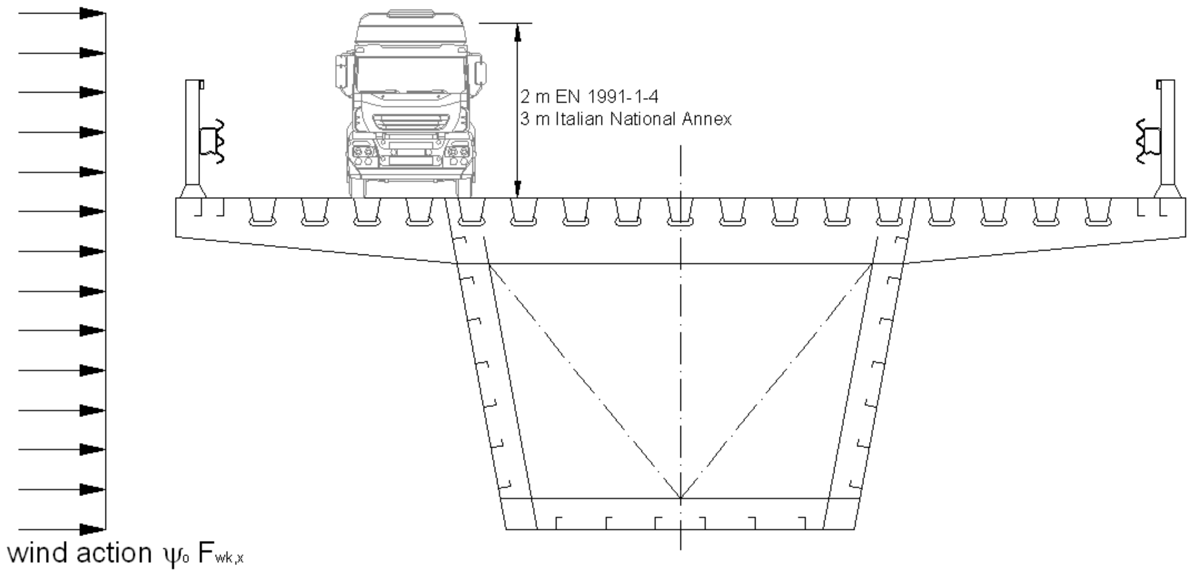

Figure 10.9 Transverse wind force (loaded bridge)

In the longitudinal direction 'y' the wind action is assumed equal 25% $F_{w,x}$.

The vertical action, according to *EN1991-1-4*, is given by

$$F_{w,z} = q_p(z_e) \cdot C_{f,z} \cdot A_{ref,z}, \tag{10.13}$$

where the vertical coefficient $C_{f,z}$ can be assumed equal to ±0.9, the most unfavourable, and the reference area $A_{ref,z}$ is the horizontal projection of the bridge deck. Finally, it is $F_{w,z}$=±13,60 kN/m, applied with an eccentricity equal to $d/4$=2,9 m.

10.3.1.5 Thermal actions

According *EN1991-1-5:2003*, two different contributions can be considered for thermal actions: a uniform temperature variation and a non-uniform temperature, accounting for example differential heating or cooling effects of intrados and extrados of the bridge.

The uniform variation can be derived from characteristic values of the air shade maximum and minimum temperature, $T_{\max}$ and $T_{\min}$ (see Sec. 6.1.3 and fig. 6.1 of *EN1991-1-5*). Assuming $T_{\max}$=40 °C and $T_{\min}$=-10 °C, diagram gives for type 1 bridges (steel bridges) $T_{\mathrm{e,max}}$=56,6 °C and $T_{\mathrm{e,min}}$=-13,3 °C (see Figure 10.10).

Obviously, in the present case the uniform variation is relevant only for longitudinal displacements, while the non-uniform temperature variation is much more relevant. According *EN1991-1-5*, two different non uniform temperature distributions can be adopted: (i) a non-linear one, represented in **Error! Reference source not found.**Figure 10.11, more realistic, but requiring sophisticated calculations, (ii) or a linear simplified one, considering a raise in temperature of 18 °C at the extrados with respect to the intrados, or an increase of 13 °C at the intrados with respect to the extrados (see Figure 10.12).

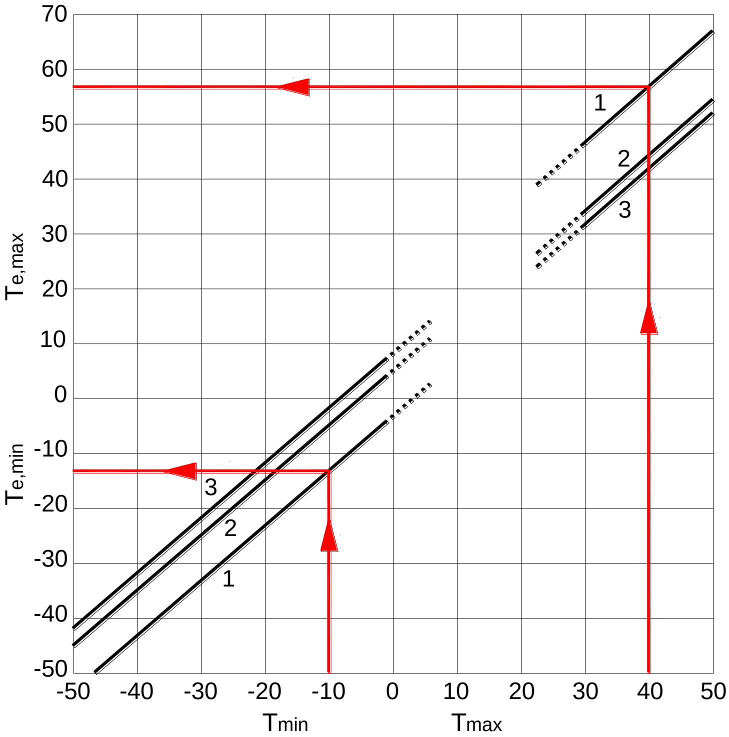

Figure 10.10 Correlation between air shade temperature $T_{\max}$ and $T_{\min}$ and bridge uniform temperature $T_{e,\max}$ and $T_{e,\min}$ (adapted from fig. 6.1 of EN1991-1-5)

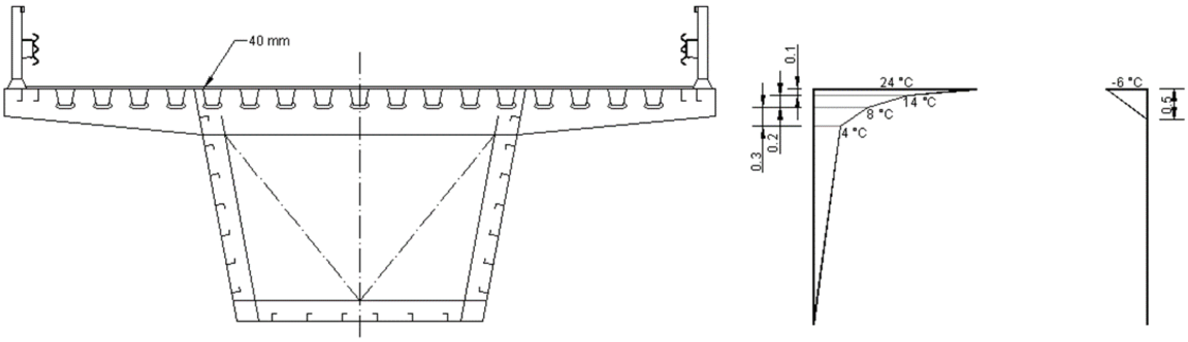

Figure 10.11 Non uniform temperature distributions for the steel bridge

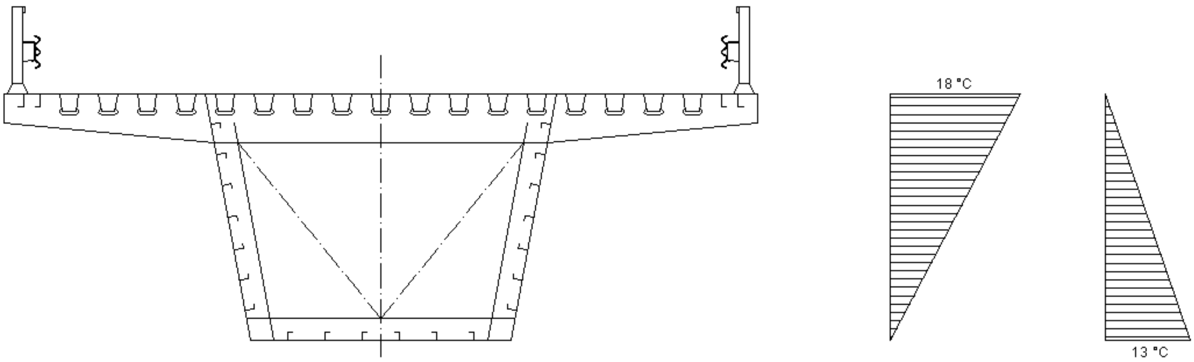

Figure 10.12 Simplified non uniform temperature distributions

10.3.2 Static calculation of the structure

The structural behaviour of orthotropic steel decks is often considered as the superposition of three separate resistant systems: a local one, where the deck plate sustains the roadway surface transferring the loads to a secondary orthotropic system composed by the deck plate and the stiffeners, supported by the transverse beams and the main beams, and the main system where the stiffened plate represents the flange of the main beams

10.3.2.1 Local effects on the deck plate and on the orthotropic deck

According to EN1991-2, effects of the wheel loads can be derived considering a 45° diffusion of the loads through the pavement and the deck plate, till to the midplane of the deck plate itself. Under this hypothesis, the mean pressure exerted by the 150 kN wheel of the tandem system on lane 1 is 522.1 kN/m^2 (see Figure 10.13a) and that exerted by the 200 kN wheel of LM2 of *EN1991-2* is 523.6 kN/m^2 (see Figure 10.13b).

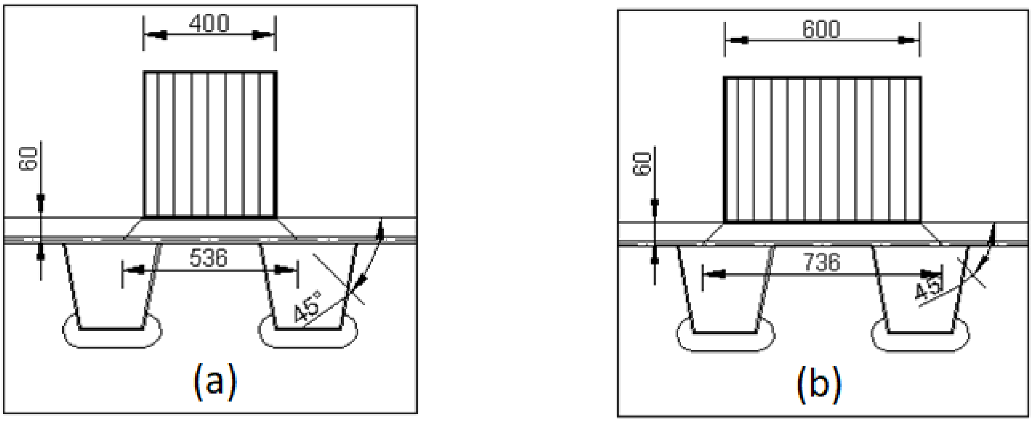

Figure 10.13 Load dispersal trough pavement and deck plate

10.3.2.2 Calculation of orthotropic deck

Beside classical analytical models, modern approaches to assessment of orthotropic steel decks consist of implementing refined finite-element model, made up essentially of 3D shell elements, reproducing a significant portion of the deck so that the actual effects on the orthotropic deck can be determined. Details of such FE models are given in Figure 10.14 concerning stiffeners and deck plate, and in Figure 10.15 concerning transverse beam.

10.3.2.3 Calculation of the main structure

The main structure is calculated simply as a three span continuous beam.

For the sake of simplicity, a constant cross section has been considered here, characterized by a moment of inertia J=0,94462 m^4.

Some relevant influence lines are reported in Figure 10.16 (sag moment in span nr. 1), Figure 10.17 (hog moment at support nr. 2) Figure 10.18 (sag moment in span nr. 2), from which effect of permanent loads and traffic loads can be easily derived.

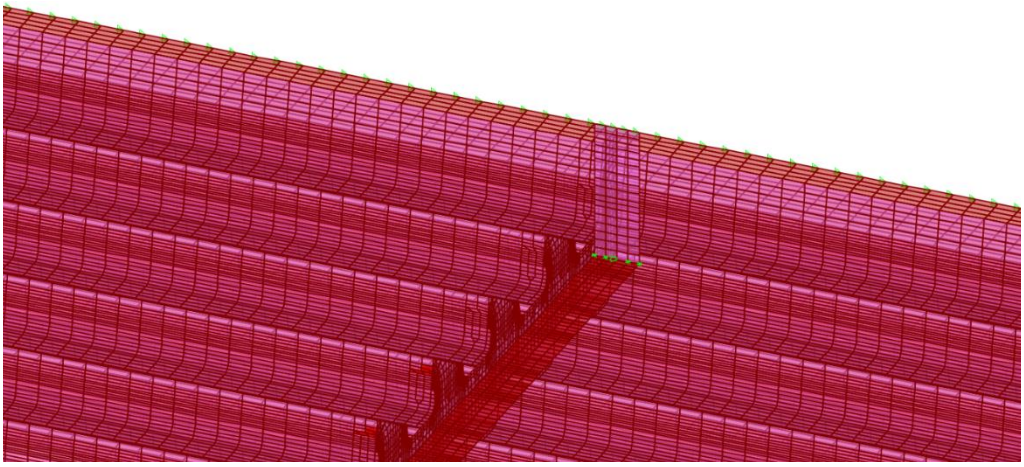

Figure 10.14 FE mesh detail for stiffeners and deck plate

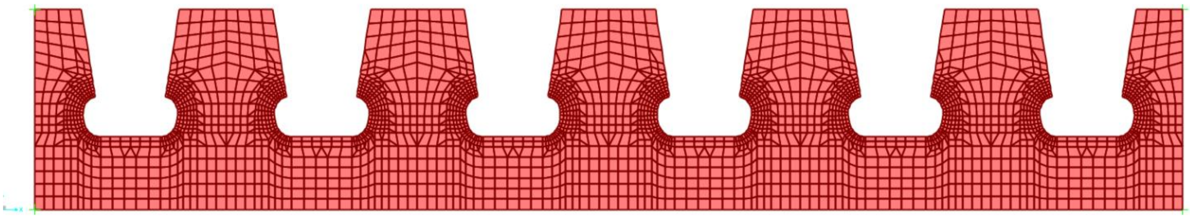

Figure 10.15 FE mesh detail for transverse beam

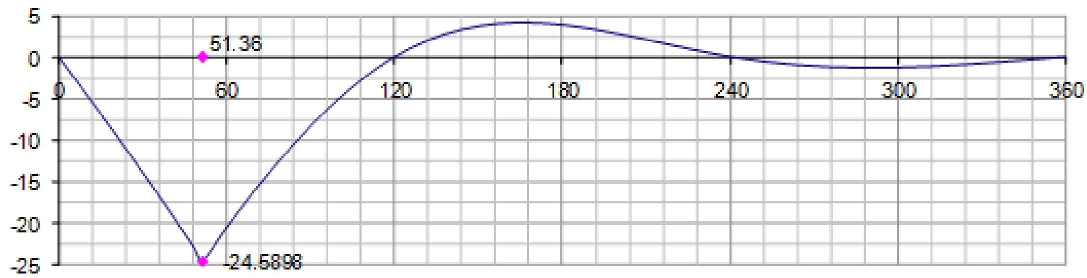

Figure 10.16 F Influence line of sag moment in span nr. 1

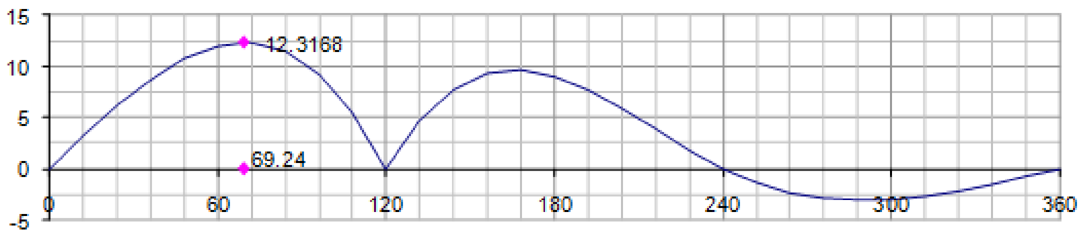

Figure 10.17 Influence line of hog moment at support nr. 2

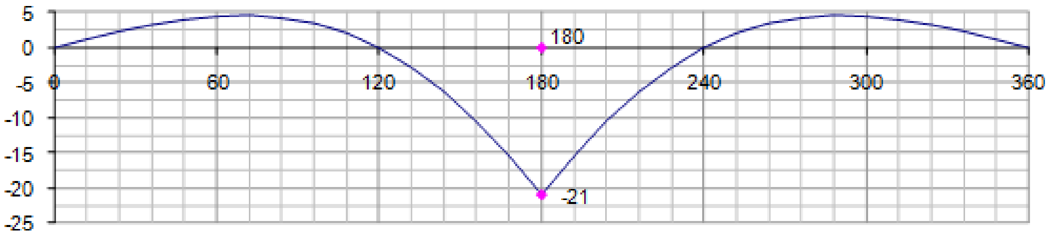

Figure 10.18 Influence line of sag moment in span nr. 2

10.3.2.4 Effects of thermal variations

For a linear non-uniform temperature distribution, a bending moment diagram like the one reported in Figure 10.19 is obtained.

Considering the simplified distributions reported in Figure 10.12 and recalling the coefficient of thermal expansion α_T is $1{,}2 \cdot 10^{-5}$ °C^{-1}, it results M_{max}=13591 kNm when the extrados is warmer than the intrados, ΔT=18 °C, and M_{max}=-9772 kNm when the extrados is colder than the intrados ΔT=-13 °C.

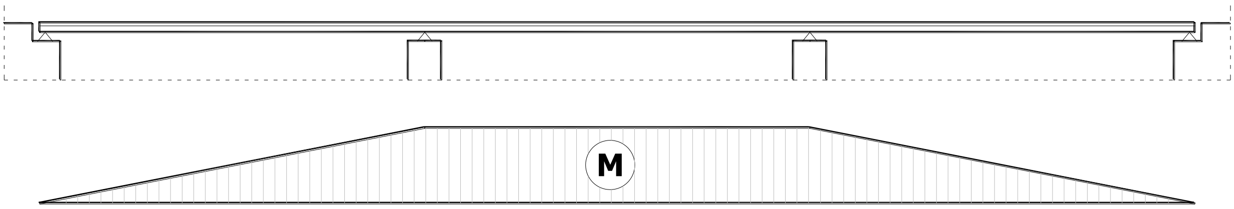

Figure 10.19 Bending moment diagram for linear non uniform temperature distribution

10.4 Example of design of a prestressed concrete bridge

The second example refers to a prestressed concrete simple supported bridge with a span of 45,0 m (Figure 10.20). The structure is made up of four equal longitudinal beams spaced 2,70 m, which sustain a 0,30 m-thick concrete slab connected by stiff transverse beams, spaced 15,0 m (Figure 10.21). The area of each beam is A_b=1,476 m^2.

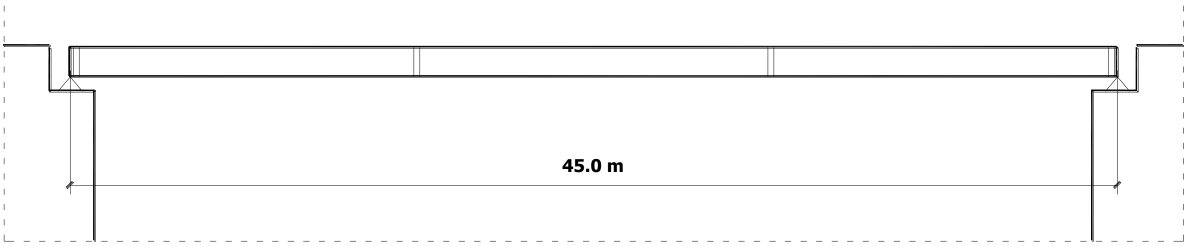

Figure 10.20 Simply supported prestressed concrete bridge

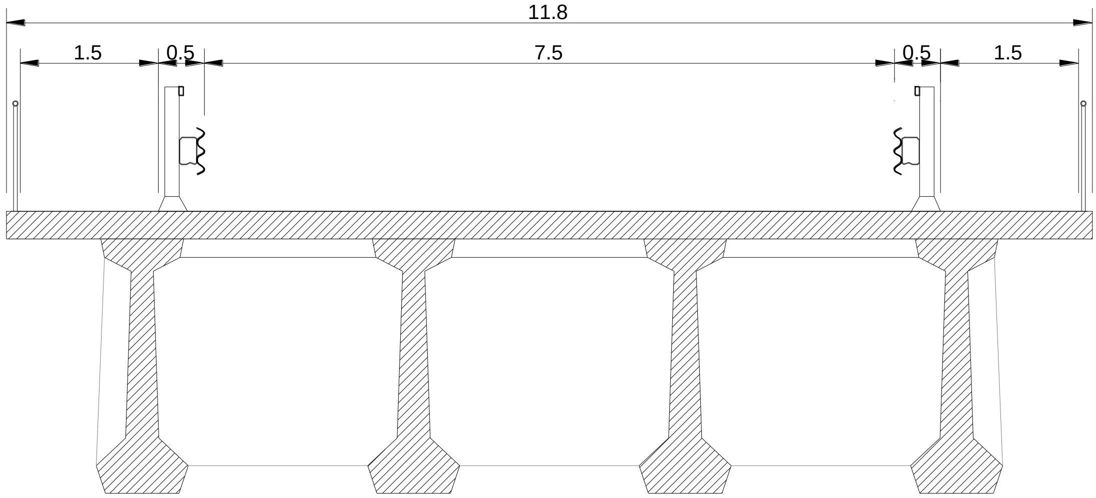

Figure 10.21 Cross section of the bridge

The roadway is 7,50 m wide, and is flanked on each side by 1,5 m wide walkways, separated from the central road by safety barriers. The bridge is located in an urban area and the distance between the bridge's intrados and an underlying roadway is 6,0 m.

10.4.1 Definition of loads

10.4.1.1 Structural self weight

Assuming for the reinforced concrete a specific weight γ =25,0 kN/m^3, the self weight of each beam is $g_b=A_b\,\gamma$ =36,9 kN/m, and the self weight of the slab is g_s=7,5 kN/m^2.

10.4.1.2 Dead loads

Dead loads include flooring, walkways, safety barriers and parapets and can be represented as a distributed load g_{add}=2,5 kN/m^2. For instance, according *EN 1991-1-1:2002* a specific weight of 23 kN/m^3 has been taken for the asphalt, and 0,60 kN/m for each parapet.

10.4.1.3 Traffic loads

Since the walkways are protected by safety barriers, the carriageway width is 7,50 m, to which correspond two notional lanes and 1,50 m of remaining area (see Figure 10.22)

In the present cases, only Load Models LM1 (see Table 10.3) and LM4 (crowd loading) of *EN1991-2* are relevant, as Load Model 2 concerns local verifications, and Load Model 3 special vehicles.

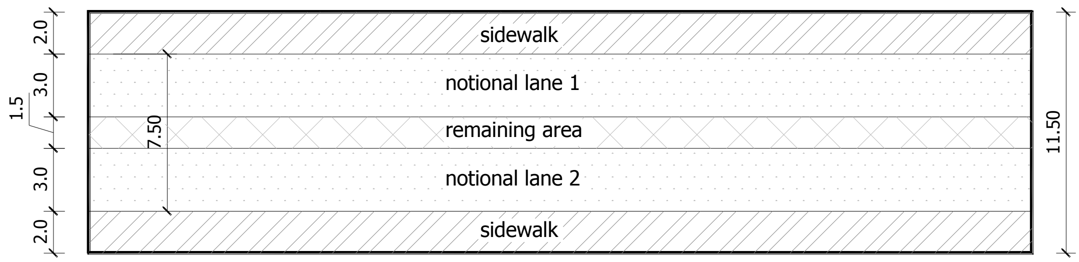

Figure 10.22 Subdivision of the carriageway

Table 10.3 LM1 traffic loads

Conventional lane	Q_k [kN]	q_k [kN/m^2]
Lane 1	300	9.0
Lane 2	200	2.5
Residual area	0	2.5

Regarding crowd loading LM4, its nominal value is 5.00 kN/m^2, while combination value is 2,50 kN/m^2.

10.4.1.4 Wind action

Using the same procedure already described in 10.3.1.4, and considering that the bridge is in an urbanized area, the terrain can be classified in category IV, for which z_0=1,0 m, $z_{\min}$=10,0 m, k_r=0,262, while the reference height z_e above the ground is z_e=6,0 m+1,53 m=7,53 m (Figure 10.23).

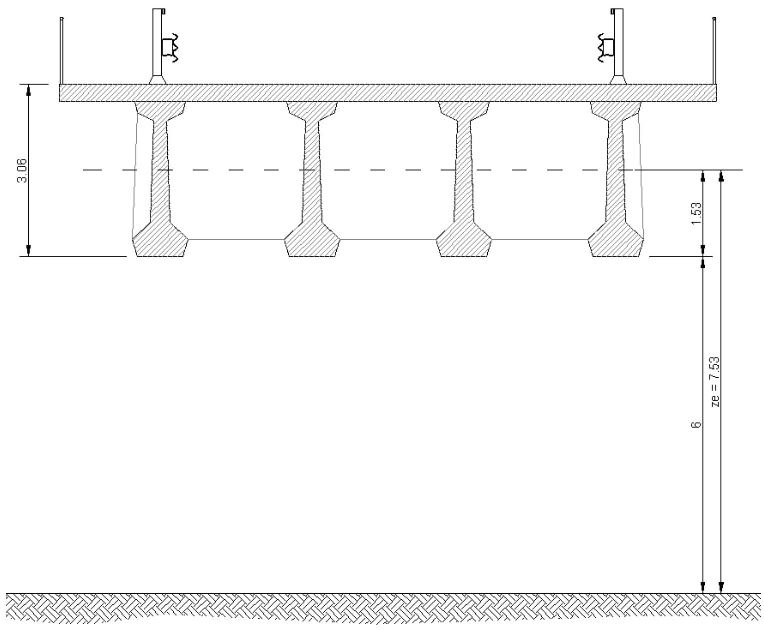

Figure 10.23 Reference height

For unloaded bridge, it results $q_p(z_e)$=0,54 kN/m²; C_{fx}=1,669; d_{tot}=4,26 m, so that $F_{wk,x}$=3,84 kN/m.

For loaded bridge (Figure 10.24), instead, it results $q_p^*(z_e)$=0,324 kN/m²; C_{fx}=1,80 (C_{fx}=1,916 according the Italian NAD); d_{tot}=5,06 m (d_{tot}=6,06 m), so that $F_{wk,x}$=2,95 kN/m ($F_{wk,x}$=3,76 kN/m).

The longitudinal force is $F_{wk,y}$=25% $F_{wk,x}$=0,738 kN/m.

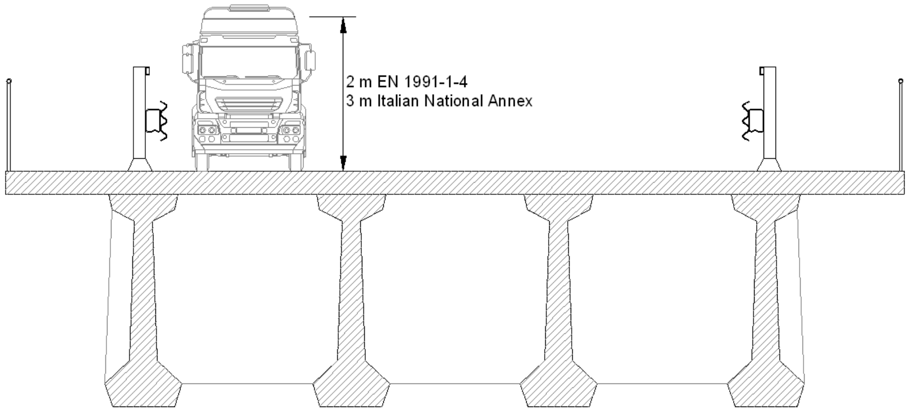

Figure 10.24 Loaded bridge (wind actions)

Regarding the vertical action, which is applied with an eccentricity of 2,95 m, assuming again $C_{f,z}$=±0,90, finally it results $F_{w,z}$=±5,73 kN/m.

10.4.1.5 Thermal actions

Of course in the present case thermal actions are generally relevant only for displacements, except in case nonlinear thermal distributions are considered, but this latter case will not be considered here.

The uniform variation can be derived from characteristic values of the air shade maximum and minimum temperature, $T_{\max}$ and $T_{\min}$ (see Sec. 6.1.3 and fig. 6.1 of *EN1991-1-5*). Assuming $T_{\max}$=40 °C and $T_{\min}$=-10 °C, diagram gives for type 3 bridges (concrete bridges) $T_{\mathrm{e,max}}$=41,7 °C and $T_{\mathrm{e,min}}$=-1,8 °C (see Figure 10.25), while simplified linear non uniform distributions are reported in Figure 10.26.

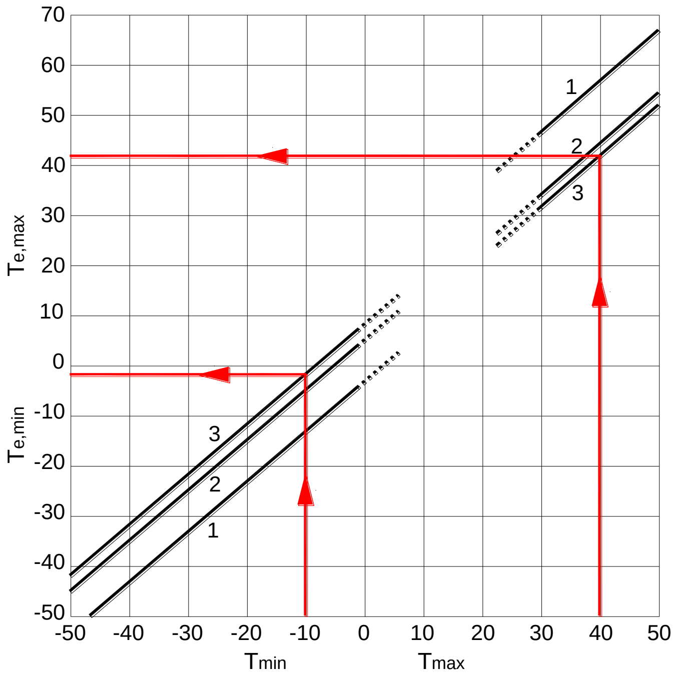

Figure 10.25 Correlation between air shade temperature T_{max} and T_{min} and bridge uniform temperature $T_{e,max}$ and $T_{e,min}$ (adapted from fig. 6.1 of EN1991-1-5)

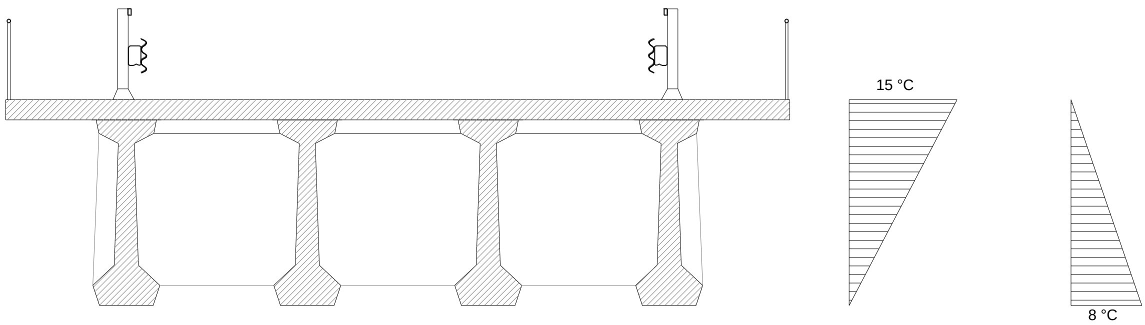

Figure 10.26 Simplified non uniform temperature distributions

10.4.2 Stress assessment

The transverse influence line for this kind of bridges can be determined according the Courbon-Engesser method.

10.4.2.1 Transverse influence line for lateral beam

Considering the influence line of the lateral beam, the most severe effect in the lateral beam itself are obtained with the load arrangement illustrated in Figure 10.27, when LM1 is taken into account, and with the load arrangement illustrated in Figure 1.28 when the LM4 (crowd loading) is considered.

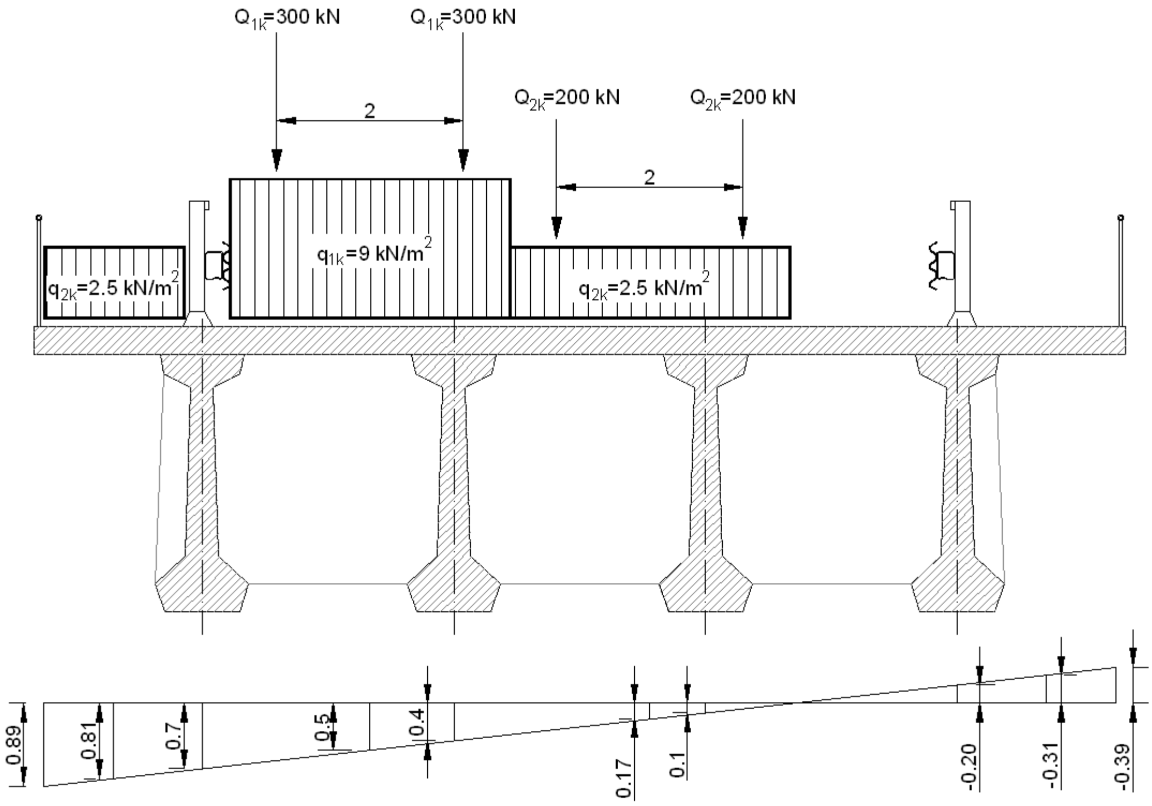

Figure 10.27 LM1 arrangement to maximize effects in lateral beam

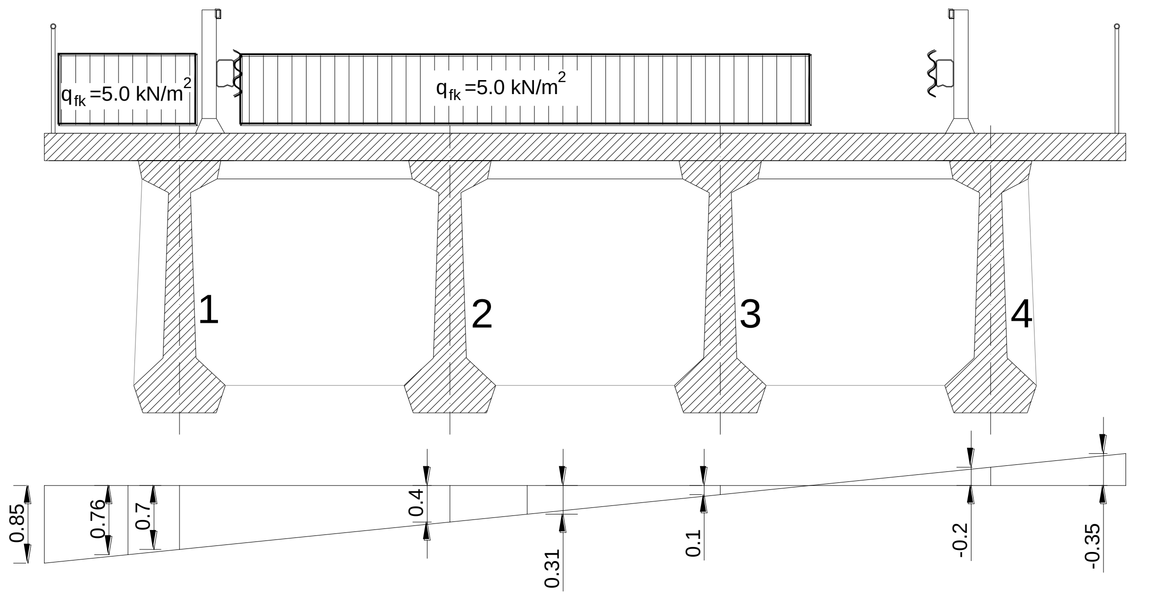

Figure 10.28 LM4 arrangement to maximize effects in lateral beam

10.4.2.2 Influence line for transverse beam

The Courbon-Engesser approach allows to derive also the influence line of shear forces or bending moments in the transverse beam, which behaves like a beam indirectly loaded.

The load arrangement of LM1 which maximize bending moment in the left span of the transverse beam is reported in Figure 10.29, while Figure 10.30 refers to LM4 minimizing it.

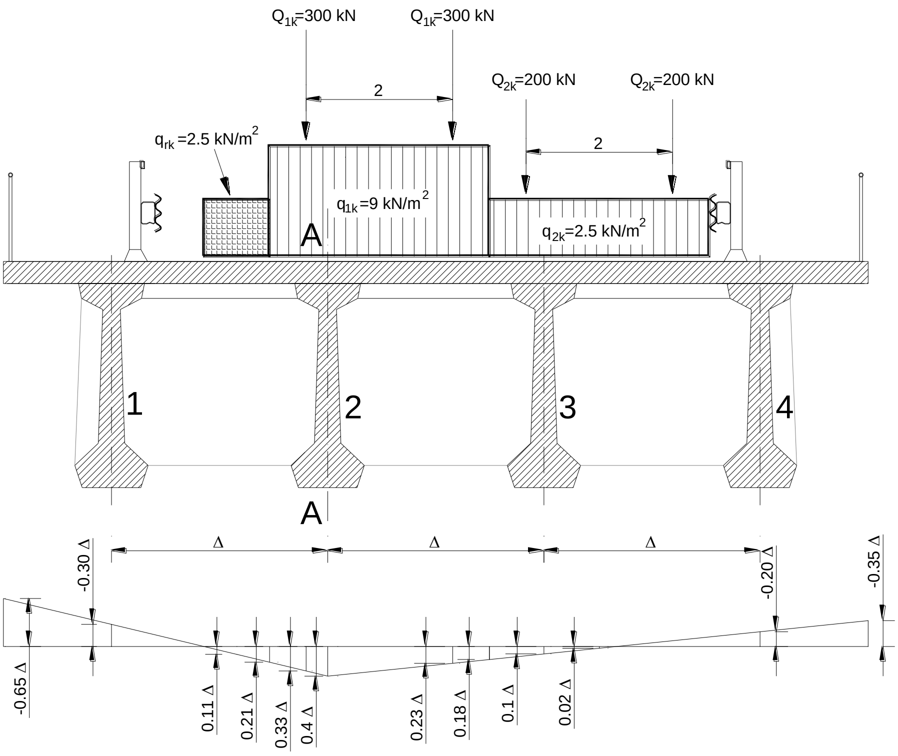

Figure 10.29 LM1 arrangement to maximize bending moment in left lateral span of transverse beam

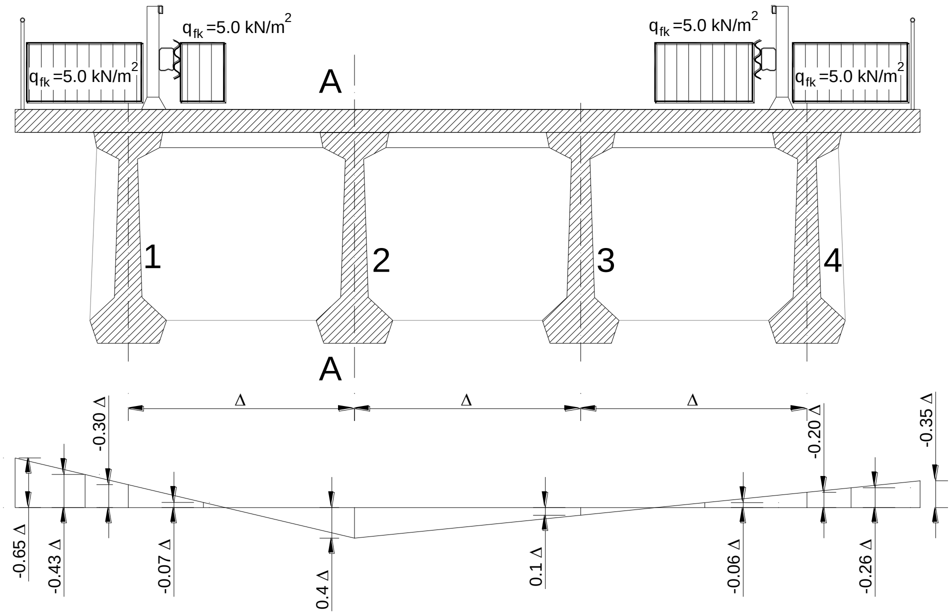

Figure 10.30 LM4 arrangement to minimize bending moment in left lateral span of transverse beam

10.5 Conclusions

The application of Eurocodes with reference to some common, but relevant, bridge design case studies has been illustrated.

It must be highlighted that Eurocodes are so flexible that they can be applied, with little adaptation even in cases not explicitly covered such as (i) for the design of composite bridges with unusual cross sections, when steel is embedded in concrete and rigid connectors are used (Figure 10.31) (ii) for the design of jetties, which are subjected to waves actions (Figure 1.32) (iii) even in case of repair, rehabilitation and seismic upgrading of existing historical masonry bridges (Figure 10.33) (Croce N. et al., 2018), where, for example, steel micropiles aim non only to deepen to foundations, but also to strengthen the pier body and also to prevent scour of piers (Figure 10.34).

Figure 10.31 Composite bridge with embedded composite cross section [© reprinted with author's permission]

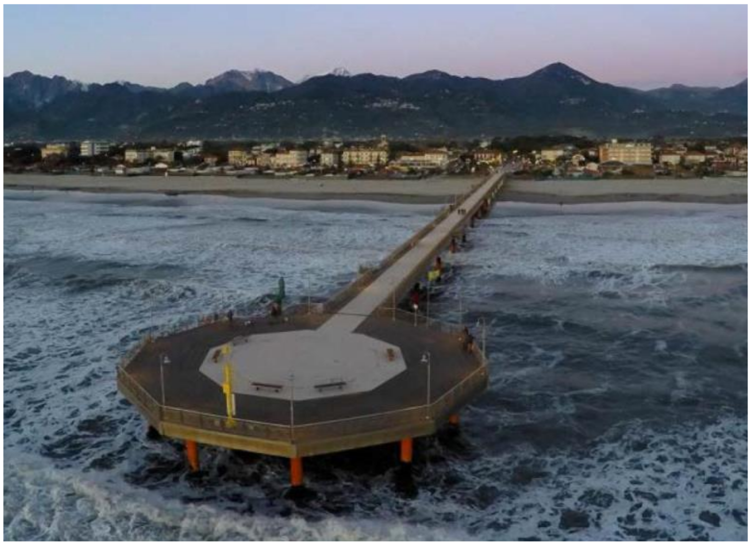

Figure 10.32 Steel jetty [© reprinted with author's permission]

Figure 10.33 Repair, rehabilitation and seismic upgrading of an existing historical masonry bridge damaged by flooding [© reprinted with author's permission]

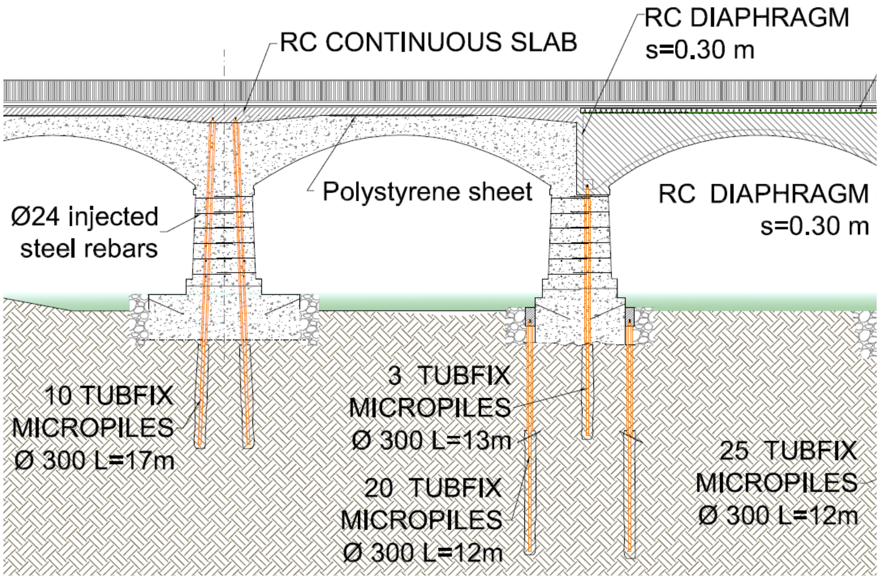

Figure 10.34 Pier reinforcement with micropiles (adapted from Croce N. et al. 2018)

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CHAPTER 11

THE STATE OF EUROCODES IMPLEMENTATION IN THE NON-EU COUNTRIES IN THE BALKAN REGION

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11 The state of Eurocodes implementation in the non–EU countries in the Balkan Region

11.1 Introduction

The EN Eurocodes are a series of 10 European Standards, EN 1990 - EN 1999, providing a common approach for the design of buildings and other civil engineering works and construction products[1].

The interest in the Eurocodes adoption and implementation in the Balkan region is based on the opportunity for an advanced common standardization environment, adaptable to the local requirements of each country (i.e. geographical, geological or climatic conditions) and allowing selection of the level of safety. The other important benefit is the fact that the Eurocodes are a comprehensive design tool, which over a mid- to long-term period intend to cover additional fields of design, such as protection of the environment, use of natural resources, energy efficiency, safety-and health conditions and security.

Moreover, the adoption and implementation of Eurocodes will help the Candidate Countries to fully implement EU acquis at the time of accession and support the Potential Candidate Countries (and Horizon 2020 associated countries) to progressively align with the EU acquis.

This chapter gives an overview of the current state of the Eurocodes implementation in non-EU countries in the Balkan region, as it was presented in the country reports delivered by the national representatives on the Workshop "The way forward for the Eurocodes implementation in the Balkans, held in Tirana, 10-11 October, 2018 and from the filled – in questionnaires (see the JRC Report by Athanasopoulou et al., 2018).

The main objective of the activities presented herein was to focus on:

- the implementation of the Eurocodes in the national regulatory framework in the Balkan countries;
- the introduction of the concept of the Community of Practice (CoP) related to the above objective.

11.2 Brief summary of activities carried out within the framework of the JRC E&I Action

In line with the EU Enlargement and Neighbourhood policy, the following non-EU countries in the Balkan region were identified: Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Kosovo[2], Montenegro, Serbia and Turkey, as well as Moldova, that belongs to the European neighbouring countries of Eastern Europe.

In each of the non-EU countries in the Balkan region several different groups of national stakeholders were identified:

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[1] https://eurocodes.jrc.ec.europa.eu/

[2] This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.

- National authorities and policy decision makers (Ministries of construction, Ministries of infrastructure, etc.);
- National Standards Bodies (NSBs);
- Professional users of standards (Design and construction companies, Industry organizations, National Financial Chambers, Chambers of professionals involved in design and engineering, etc.);
- Institutions that will stream the determination of the NDPs, NAs, elaboration of maps for climatic and seismic actions and the application and training on the Eurocodes (Universities, Research institutions, Academies of Sciences, etc.);
- Chairmen of TC250 Mirroring Committees and members of the working groups.

The organization of four workshops (Figure 11.1) with representatives of the Balkan countries was carried out in order to provide scientific and technical contribution in the context of the JRC support to DG GROW on worldwide promotion of the Eurocodes, and to support Accession and Candidate Countries within the framework of the JRC E&A Action.

The first workshop on the "Adoption of the Eurocodes in the Balkan region" was held on 5-6 December 2013 in Milan[3] and at the Joint Research Centre of the European Commission (JRC) at Ispra, Italy (Apostolska et al., 2013). It was organized by DG JRC with a visit of the European Laboratory for Structural Assessment (ELSA) and supported by the JRC Enlargement and Integration Action. The workshop was focused on the progress and specific needs for the adoption and implementation of the Eurocodes and related EN standards in the Balkan region. The important conclusion was that most of the non-EU countries in the Balkan region are planning to use the Eurocodes as primary standards. There was also good progress on Eurocodes translations, especially on EN 1990, EN 1991 and EN 1992. However the process of elaboration of Nationally Determined Parameters (NDPs) and National Annexes (NA) was, at that time, in the initial phase. In most of the countries, there was reported a lack of relevant institutional support for adoption and implementation of the Eurocodes, so creating a regional platform for collaboration was pointed as one of the drivers in the process.

The second workshop on "Building capacities for elaboration of NDPs and NAs in the Balkan region" was held on 4-5 November 2014 in Skopje[4]. It was focused on further adoption and implementation of the Eurocodes in non-EU countries in the Balkan region. The main goal was to assess recent progress, difficulties and needs for the definition of the NDPs and NAs since the first workshop held in 2013, and to boost regional collaboration for cross-border harmonization of NDPs (Apostolska et al., 2014). Based on compiled questionnaires and country report presentations delivered at the workshop significant progress of definition of NDPs was observed. Most of the non-EU countries in the Balkan region (except Bosnia and Herzegovina and Turkey) had started with the definition of NDPs. Albania and Serbia were the most advanced with around 60% of NDPs already defined. The former Yugoslav Republic of Macedonia reported that 71% of NAs are in the phase of public enquiry. The average percentage of acceptance of the recommended values for the NDPs that have been already defined was more than 80%. This percentage was in line with the average of 73% acceptance calculated for the EU Member States and based on the uploaded 67.8% of NDPs in the JRC Eurocodes NDPs database (*data refers to 22.04.2016*).

The third workshop on "Elaboration of maps for climatic and seismic actions for structural design in the Balkan region" was held on 27-28 October, 2015 in Zagreb, Croatia[5]. The Workshop was aimed at further adoption and implementation of the Eurocodes in the non-EU countries in the Balkan region and, in particular, to strengthen the capacities of

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[3] http://eurocodes.jrc.ec.europa.eu/showpage.php?id=2013_12_WS_Balkan

[4] http://eurocodes.jrc.ec.europa.eu/showpage.php?id=2014_11_WS_Balkan

[5] http://eurocodes.jrc.ec.europa.eu/showpage.php?id=2015_10_WS_Balkan

stakeholders for the elaboration of maps for climatic and seismic actions (Formichi et al, 2016). The main conclusion was that the elaboration of seismic hazard maps was in the advanced phase while the elaboration of maps for climatic actions was lagging behind, mainly due to insufficient data being available. The process of publication of NAs to the EN Eurocodes parts which were relevant to the objectives of the Workshop was in its initial phase in all countries, except in the former Yugoslav Republic of Macedonia, where all NAs had already been published (the maps were foreseen to be included by the end of 2016). Montenegro was in an advanced stage also with already elaborated NAs to EN1998-1and NAs to EN1991-1-3, EN1991-1-4 and EN1991-1-5 foreseen for 2016.

The fourth workshop on "Current status of the Eurocodes in the Balkan region" was held on held on 8-9 June 2016 in Skopje[6] was focused on further adoption and implementation of the Eurocodes in non-EU countries in the Balkan region. It was organized by the Institute of Earthquake Engineering and Engineering Seismology (IZIIS), Skopje in cooperation with the DG JRC and with CEN & CENELEC, within the frame of the CEN&CENELEC 12th Annual meeting. The main objectives of the workshop were to: (1) assess recent progress, difficulties and needs (current status) for adoption and implementation of the Eurocodes in non-EU countries from the Balkan region since the last workshop held in Zagreb on 27-28 October 2015; (2) explore opportunities to facilitate the process of adoption and implementation of the Eurocodes in the Balkan region and (3) announce the possibilities DG JRC will offer in opening its research infrastructures to external users linked to the Enlargement and Integration Action of DG JRC. All countries reported significant progress in the process of adoption of the Eurocode since the first workshop in Milan (2013). Most National Standardisation Bodies had adopted the Eurocodes as standards, in parallel with existing national codes that were part of the National regulatory framework. Also, in most countries practitioners were using National codes and Eurocodes in parallel (as long as National regulatory frameworks was respected). However, in 2016 none of the countries had adopted and implemented the Eurocodes in the national regulatory framework.

Figure 11.1 JRC E&I Action training workshop in the period of 2013-2016, towards the adoption and implementation of the Eurocodes in the non-EU members Balkan countries

The round table at the last workshop (June, 2016) opened the floor for discussion on how to further facilitate the process of adoption, implementation and promotion of the

[6] https://eurocodes.jrc.ec.europa.eu/showpage.php?id=2016_06_WS_Balkan

Eurocodes in the non-EU countries from the Balkan region. Related to participants' discussion about observed obstacles in this process, the objectives of further technical assistance was proposed to be directed at the three levels (Apostolska, 2016):

- National regulatory framework level – it was already noted that most of the National Standardisation Bodies have adopted the Eurocodes as standards, but none of the countries had adopted and implemented the Eurocodes in the National regulatory framework.
- Implementation level – assistance in training of practitioners (design engineers) to enable their understanding and use of the Eurocodes in day-to-day design practice (level 3 of training – comprehensively describes design examples of a number of typical structures using a particular package of Eurocodes).
- Maintenance and upgrading level – increase awareness of the National Authorities and National Standardization Bodies of the need for maintaining the existing Eurocodes (technical, editorial, scientific issues) and keep pace with the coming-up second generation of the Eurocodes.

11.3 Workshop on the state of the Eurocodes implementation in the non-EU countries in the Balkan region

In order to overcome the first gap reported in the previous section and facilitate the process of the Eurocodes implementation in the national regulatory framework, a two-day workshop was held on 10-11 October, 2018 in Tirana[7], (Figure 11.2). It was organized by DG JRC, supported by the JRC Enlargement and Integration Action, DG GROW, CEN-CENELEC Management Centre and CEN/TC250 Structural Eurocodes.

The workshop and the round table discussion served the following objectives:

- Assess the level of commitment of the National Authorities in adopting the Eurocodes;
- Assess the level of harmonization of national policy/legislation with EU regulatory framework;
- Identify challenges and impediments for the Eurocodes implementation at national regulatory framework level and discuss possible actions;
- Assess the progress of definition of Nationally Determined Parameters (NDP) and identify needs for (possible) review of already defined NDPs;
- Facilitate regional cooperation in the Eurocodes implementation;
- Present case studies of EU countries that have successfully implemented the Eurocodes in the national regulatory framework;
- Facilitate exchange of views, knowledge and information between EU experts and representatives of non-EU countries in the Balkan region.

[7] https://eurocodes.jrc.ec.europa.eu/showpage.php?id=2018_10_WS_Balkan

(a) (b)

Figure 11.2 (a) Workshop leaflet "The way forward for the Eurocodes implementation in the Balkans"; (b) Group photo of the Balkan countries representatives (Athanasopoulou et al., 2018).

The total number of participants was 77, (see Figure 11.3), wherein 35% were representatives from National Authorities (NA) and policy decision makers, 21% were from the National Standardization Bodies (NSB), 23% were professional users of standards and 21% were representatives from the institutions who will stream elaboration of NDPs and training on the Eurocodes.

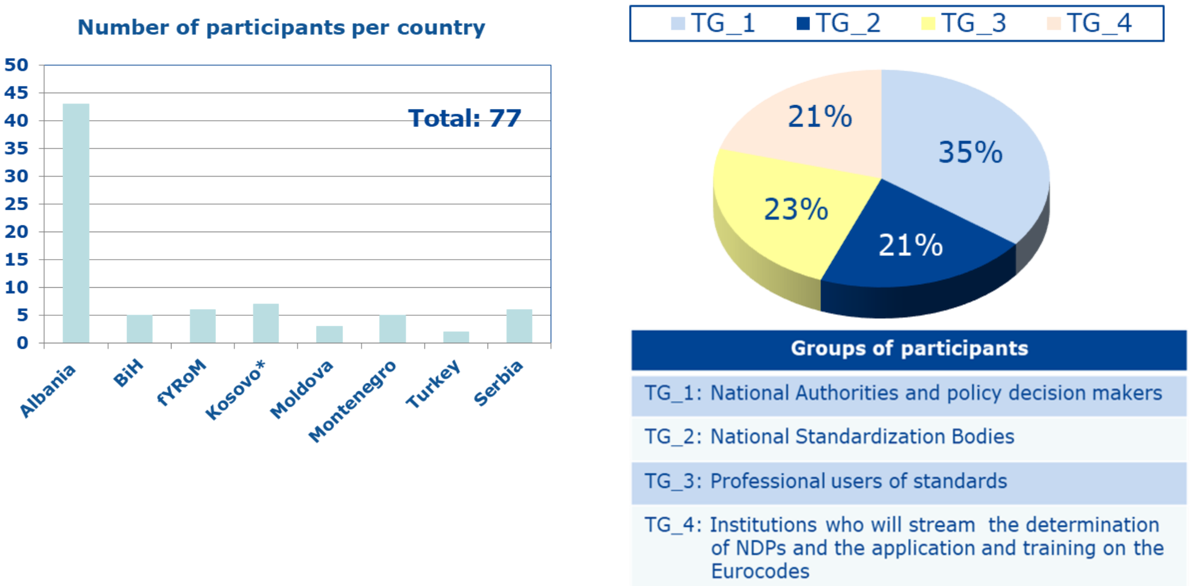

Figure 11.3 Workshop – Total number of participants and target groups (TGs)

The programme of the workshop was composed of the following parts:

- Presentations of non-EU Balkan countries about status of implementation of the Eurocodes (standards and legislation); discussion on their specific problems and needs;
- Lectures delivered by experts from the European Commission, CEN/CENELEC and EU member states with recommendations on the way forward for the implementation of Eurocodes in the national regulatory framework;
- Presentation of case studies sharing EU MS experience and serving as best practice examples for non-EU Balkan countries;
- Round table discussions regarding implementation of the Eurocodes in the Balkan region, especially their implementation in the national regulatory framework – conclusions and recommendations for the way forward.

The questionnaire to assess the state of implementation of the EN Eurocodes in the national regulatory framework (NRF) was elaborated and consisted of two parts, Part A and Part B (Figure 11.4). Part A was dedicate to collect information regarding:

- Translation and publishing of the Eurocodes;
- Progress of elaboration of NDPs and acceptance of RVs and
- Publishing of NAs.

Responsible for delivering this part was a representative from the NSB from each participating country.

QUESTIONNAIRE TO ASSESS THE STATE OF IMPLEMENTATION OF THE EN EUROCODES IN THE NATIONAL REGULATORY FRAMEWORK IN THE BALKAN REGION							
PART A: EN EUROCODES PARTS, NATIONALLY DETERMINED PARAMETERS AND NATIONAL ANNEXES							
(To be compiled by the representative(s) of the National Standardisation Body or National Mirror Committee to CEN/TC250)							
Representative:							
Affiliation:							
Position:							
Email:							

EN Eurocode parts	**Was the EN part translated in the National language?**	**Was the EN part pubslihed as National Standard?**		**Definition of NDPs**		**Was the National Annex (NA) to the EN part published?**	
	(Yes/No)	(Yes/No)	If **"No"**, please provide envisaged date of publishing	Please assess the progress of NDPs definition in %	Please provide the % of acceptance of the Recommended Values for the defined NDPs	(Yes/No)	If **"No"**, please provide envisaged date of publishing
EN 1990: BASIS OF STRUCTURAL DESIGN							
EN 1990 - Annex A1							
EN 1990 - Annex A2							
EN 1991: ACTION TO STRUCTURES							
EN 1991-1-1							
EN 1991-1-2							
EN 1991-1-3							
EN 1991-1-4							
EN 1991-1-5							
EN 1991-1-6							
EN 1991-1-7							
EN 1991-2							
EN 1991-3							
EN 1991-4							

Figure 11.4 Questionnaire - Part A*: selected view*

Part B addressed (Figure 11.5) three different groups of questions:

- Eurocodes in the NRFs;
- Use of Eurocodes in public procurements and for the design of important structures and

- Obligatory use of any EN part.

This part of the questionnaire was filled-in by National Authorities representative from each participating country.

QUESTIONNAIRE TO ASSESS THE STATE OF IMPLEMENTATION OF THE EN EUROCODES IN THE NATIONAL REGULATORY FRAMEWORK IN THE BALKAN REGION	
PART B: EUROCODES IMPLEMENTATION IN THE NATIONAL REGULATORY FRAMEWORK (NRF)	
(To be compiled by the representative(s) of the National Authority)	
Representative:	
Affiliation:	
Position:	
Email:	
Part B.1 Are the Eurocodes already incorporated in the national technical regulation ? If NOT, please briefly explain why. Is there a National Action Plan for the implementation of the Eurocodes in the NRF?	
Part B.2 Does the NRF enforce the use of the Eurocodes in public procurement and/or for design of certain categories/types of structures? If YES, please list these categories/types.	
Part B.3 Is the use of any EN Parts obligatory in your country? If YES, please list these EN Parts.	

Figure 11.5 Questionnaire - Part B*: selected view (cont.)*

During the second day of the workshop representatives from each participating country delivered a country report regarding the state of the Eurocodes implementation.

The summary of the collected questionnaires and country reports is presented in Table 11.1 and

Table 11.2, below.

The most advanced of the non-EU Balkan countries in the process of publishing of NAs are the former Yugoslav Republic of Macedonia where all NAs are already published and should be only completed with seismic hazard maps (adopted on the last meeting of the TC250 Mirror Committee, held on November 7, 2018) and climatic maps (in public enquiry) and Serbia with 46 published NAs. Good progress is observed in Montenegro, Moldova and in Bosnia and Herzegovina which made huge steps from the start of this action (2013) (Table 11.1).

Regarding insertion of the Eurocodes in the NRF, except (partially) in Bosnia and Herzegovina, none of the countries have adopted Eurocodes as mandatory building codes. Some of the countries refer to them as mandatory in certain public procurement but the overall conclusion is that their implementation in the NRF is lack behind their elaboration as national standards. Within this line, presented case studies sharing EU MS experience in the topic are of outmost significance for the Balkan countries.

Table 11.1 Summary of the Questionnaire – Part A

Country	EN part translated	EN part published as NS	Progress of NDPs	Acc. of RVs	NAs published	Comments
Albania	All, except EN1995 and EN1999	All, except EN1995 and EN1999	50%-100%	50%-100%	0	/
BiH	100%	100%	All in EN1990, EN1991-1-1 to EN1991-1-5 and EN1998-1	Diff.	8	Networking, Czech Office for standards, metrology and testing
FYROM	100%	100%	All, except climatic maps	Around 90%	All, except seismic hazard and climatic maps	/
Kosovo[1]	In progress	100%	0	0	0	Networking with DGS Albania
Moldova	100%	100%	All in EN1990-EN1995	90%	16	Networking with Romanian standards assoc., TU – Bucharest, Czech Office for standards, metrology and testing
Montenegro	44% (26 parts)	44% (26 parts)	n/a	Diff.	44% (26 parts)	Twinning with NSB from Austria
Serbia	27% (16 parts)	100%	100%, except EN1996 and EN1997	Diff.	80% (46 parts)	/
Turkey	44%	100%	0	0	1	Turkish Building Earthquake Code (2018)

Table 11.2 Summary of the Questionnaire – Part B

Country	B1. Eurocodes in NRF	B2. Eurocodes in public procurements/ certain categories of structures	B3. Obligatory use of any EN part
Albania	No	No	No
BiH	Eurocode 2 and Eurocode 6	Eurocode 2 and Eurocode 6	BAS EN related standards
FYROM	No	No	No
Kosovo*	No – (roadmap for adoption, implementation and promotion of the Eurocodes)	No (by law) - (in practice for high risked structures)	No
Moldova	No – approved NAP, 2014-2020 (Decision no. 933, dated 2014)	No	No
Montenegro	Anticipated – end of 2019 (NAP for adoption and implementation dated 2014)	No	No
Serbia	n/a	Usually for most important infrastructure projects (parallel use)	n/a
Turkey	No - the construction engineering practices in Turkey is largely governed by the provisions in the Turkish Building Earthquake Code (TBEC), enforced 01.01.2019. Some sections of the Eurocode parts and some EN standards are incorporated to TBEC, (EN1990 Annex D; EN1992-1; EN1993-1-3; EN1995 (12); EN1996-1 (11); EN15129; EN1997 (16))		

11.4 Views on the way ahead

As a possible way of go ahead, the following activities have been identified:

- To explore possibilities for training of practitioners (design engineers) to enable their understanding and use of the Eurocodes in their day-to-day design practice (level 3 of training – comprehensively describes design examples of a number of typical structures using a particular package of Eurocodes) – implementation level.
- To launch bilateral projects for building national capacities for adoption and implementation of the Eurocodes (positive examples – BiH and Czech Standardization Institute, KSA and Albanian Standardization Agency, Moldova and TU Bucharest and Czech Standardization Institute).
- To increase awareness of the National Authorities and National Standardization Bodies of the need for maintaining the existing Eurocodes (technical, editorial,

scientific issues) and keep pace with the coming-up second generation of the Eurocodes – maintenance and upgrading level.

- To create a Community of Practice to provide continuous support in the future actions related to the Eurocodes implementation in the Balkans and to assist in the process of their maintenance and updating once they will be adopted.

Acknowledgement

The activities presented in the chapter were carried out during expert engagement of Roberta Apostolska (Expert Contract CT-EX2012D125987-103). She expresses her gratitude to the Joint Research Centre of the European Commission (JRC.E04 Unit) for the entrusted task.

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Workshop "The way forward for the Eurocodes implementation in the Balkans" - Concept Note 30.05.2018– for distribution

CHAPTER 12

THE ENGINEERING CHAMBERS IN SUPPORT OF THE EUROCODES IMPLEMENTATION IN THE BALKANS

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12 The Engineering Chambers in support of the Eurocodes implementation in the Balkans

12.1 Continuous Professional Development (CPD) of engineers as a way to the Eurocodes implementation in the Balkans

12.1.1 CPD for Engineers within ECEC

The European Council of Engineers Chambers[1] (ECEC) on its 10th General Assembly meeting in Athens, held on October 12th 2013, established a Working Group (WG) on Continuous Professional Development (CPD). Elected president of WG was Ph.D. Dragoslav Sumarac Civ.Eng.

The Serbian Chamber of Engineers[2] was appointed as the responsible for the organization of CPD lectures in ECEC member countries.

The aim of the WG on CPD was the implementation for the Joint European program on the improvement and coordination of a Common European CPD and a National permanent training program. Further, the WG is engaged in providing organizational technical requirements for the performance of the program, recording the participants of the CDP programs for numbering of the permanent CPDP (Continuous Professional Development Points) and committing other business that are important for the implementation of the training program. Lastly, the WG is committed in making reports of the work for the Assembly of Serbian Chamber of Engineers and for the Executive Board of the European Council of Engineers Chambers. More about CPD programe can be seen on the official web site of ECEC (https://www.ecec.net/activities/cpd-lectures/).

12.1.2 CPD for engineers within the Serbian Chamber of Engineers

The Assembly of the Serbian Chamber of Engineers adopted a decision for the Continuous Professional Development (CPD) for its members on the session held on April 25th 2014. In the decision adopted, each member of the Chamber should have 20 CPDP from the EU program and 80 CPDP from the National program within one year period. All lectures held for the Eurocodes were accordingly assigned to the EU program.

12.1.2.1 Lecture on EN 1990 "Basis of structural design" and EN 1991 "Actions on Structures"

The Serbian Chamber of Engineers in cooperation with the European Council of Engineers Chambers (ECEC) organized a lecture on the topic "EN 1990, Basis of structural design, EN 1991 (Eurocode 1), Actions on structures". The lecturer was professor Rüdiger Höffer Ph.D., CE, Ruhr-Universität, Bochum, DE. The lecture was held on 15.05.2015.

[1] https://www.ecec.net/.

[2] https://www.ingkomora.rs/cpd/index.php?id=160915.

The lecture, which was organized in 4 segments, provided insight into the important basic characteristics of European norms EN 1990 and EN 1991, as well as examples and instructions for optimizing the practical application of these norms. The structure of the lecture was the following:

- EN 1990 - Basics of designing structures
- EN 1991 Part 1-1: General Actions - Density, weight of construction, imposed loads
- Part 1-3: General Actions - Snow load
- Part 1-4: General Actions - Wind load
- Part 1-7: General facts - Random loads.

The lecture in the form of a webinar was transmitted in the National Engineers Chambers of Austria, Italy, Montenegro, Slovenia, Slovakia and Bulgaria. In the Serbian Chamber of Engineers, the lecture was attended by 225 engineers. The lecture was recorded and can be found at Serbian Chamber web site[3].

12.1.2.2 Lecture on EN1992 "Design of reinforced concrete structures"

Professor Jaroslav Halvonik gave a lecture in the form of the webinar, organized by the Serbian Chamber of Engineers and the Engineering Chamber of Slovakia, in June 2014.

The emphasis of the lecture was on reinforced and pre-stressed concrete, which is today the most used material in the construction industry, while Eurocode 2 (EN1992) is the most commonly used standard in designing structures from this material.

The lecture was focused on two of the most discussed topics that are related to design in accordance with EN-1992-1-1, such as the design of lean columns and punching of panels.

The lecture was attended by 150 engineers[4].

12.1.2.3 Lecture on Eurocode 2 "Design of reinforced concrete structures" according to EN 1992-1-1

In the organization of the Serbian Chamber of Engineers, the Engineering Chamber of Slovakia and the European Council of Engineering Chambers, Ph. D. Vladimir Benko, B.Sc., full professor at the Faculty of Civil Engineering, University of Bratislava, and President of the Chamber of Engineers of Slovakia also gave a lecture on "Design of reinforced concrete structures according to EN 1992-1-1, Eurocode 2".

The lecture was held on 16 September in 2015, at the Engineering Chamber of Slovakia in Bratislava with live stream to the Serbian Chamber of Engineers in Belgrade, as well as in regional offices of the Serbian Chamber of Engineers in Novi Sad, Niš, Kraljevo, Valjevo and Bor.

Reinforced and pre-stressed concrete is the most used material in the construction industry, while Eurocode 2 (EN 1992) is the most widely used standard in designing constructions from this material.

308 members of the Serbian Chamber attended the lecture[5].

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[3] See at https://www.ingkomora.rs/cpd/index.php?id=160915

[4] See at https://www.ingkomora.rs/cpd/index.php?id=160915

[5] See at https://www.ingkomora.rs/cpd/index.php?id=160915

12.1.2.4 Implementation of the Eurocodes in Serbia

According to the Serbian Institute of Standardization, the following Serbian standards are transposing the Eurocodes:

- SRPS EN 1993 - Eurocode 3: Design of steel structures
- SRPS EN 1994 - Eurocode 4: Design of composite steel and concrete structures
- SRPS EN 1999 - Eurocode 9: Design of aluminum structures
- SRPS EN 1993 - Eurocode 3: Design of steel structures
- SRPS EN 1993-1 - Eurocode 3: Design of steel structures - Part 1
- SRPS EN 1993-2 - Eurocode 3: Design of steel structures - Part 2: Steel Bridges
- SRPS EN 1993-3 - Eurocode 3: Design of steel structures - Part 3: Towers, masts and chimneys
- SRPS EN 1993-4 - Eurocode 3: Design of steel structures - Part 4
- SRPS EN 1993-5 - Eurocode 3: Design of steel structures - Part 5: Piling
- SRPS EN 1993-6 - Eurocode 3: Design of steel structures - Part 6: Crane supporting structures
- SRPS EN 1993-1-1:2012 - Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
- SRPS EN 1993-1-2:2012 - Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design
- SRPS EN 1993-1-3:2013 - Eurocode 3 - Design of steel structures - Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting
- SRPS EN 1993-1-4:2012 - Eurocode 3 - Design of steel structures - Part 1-4: General rules - Supplementary rules for stainless steels
- SRPS EN 1993-1-5:2013 - Eurocode 3 - Design of steel structures - Part 1-5: Plated structural elements
- SRPS EN 1993-1-6:2012 - Eurocode 3 - Design of steel structures - Part 1-6: Strength and Stability of Shell Structures
- SRPS EN 1993-1-7:2012 - Eurocode 3 - Design of steel structures - Part 1-7: Plated structures subject to out of plane loading
- SRPS EN 1993-1-8:2012 - Eurocode 3: Design of steel structures - Part 1-8: Design of joints
- SRPS EN 1993-1-9:2012 - Eurocode 3: Design of steel structures - Part 1-9: Fatigue
- SRPS EN 1993-1-10:2013 - Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties
- SRPS EN 1993-1-11:2012 - Eurocode 3 - Design of steel structures - Part 1-11: Design of structures with tension components
- SRPS EN 1993-1-12:2012 - Eurocode 3 - Design of steel structures - Part 1-12: Additional rules for the extension of EN 1993 up to steel grades S 700.

According to the lecture of professor Zlatko Markovic, held in the Serbian Chamber of Engineers in 2015, the following Eurocodes are mentioned:

- SRPS EN 1995: Design of wooden structures
- SRPS EN 1996: Design of masonry structures

All standards have been adopted, of which they are most important SRPS EN 1995-1-1:"General rules and rules for buildings" and SRPS EN 1996-1-1: "General rules and rules for buildings" adopted in the Serbian language.

Effects - Commission U250-1.8

SRPS EN 1990: Design basics

- An adopted standard in the Serbian language,
- National Annex SRPS EN 1990 / NA adopted, application in building and bridge construction;

SRPS EN 1991: Effects

- All parts were adopted in Serbian (4 parts) or English (other parts);

National contributions are in progress.

SRPS EN 1998: Seismic

- All parts were adopted in English;
- National contributions are in progress.

References

https://www.ecec.net/activities/cpd-lectures/
https://www.ingkomora.rs/cpd/index.php?id=160915

CHAPTER 13

CONCLUSIONS AND THE WAY FORWARD

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13 Conclusions and the way forward

The Eurocodes have already became common technical rules and language among engineers, facilitating the international exchange of design services within the Member States of the European Union and beyond its boundaries. The publication of the first generation of the Eurocodes in 2017 marked a tremendous achievement of 30 years of collaborative work by EU MS experts, National Standards Bodies, policy makers and regulators across Europe.

The **Eurocodes had been already accepted as National Standards in Europe by 2015**. They have also already been introduced in third counties, particularly as an important element for improving regulatory capacity and designing important infrastructure. In the same time, they are applicable for the design of simple structures, facilitating the everyday tasks of designers.

The **Eurocodes also offer each country the opportunity to adapt the standards to local conditions and needs**. The Nationally Determined Parameters provide opportunity to adapt the implementation of the Eurocodes to country-specific conditions regarding climate, seismic risk, traditions, and safety requirements.

The EU countries that have successfully implemented the Eurocodes in their regulatory system and construction design practice can serve as good practice examples for all other countries willing to adopt and implement the Eurocodes. The EU MS case studies that have been presented in this report clearly show that there are **two main approaches in the National implementation the Eurocodes**: as **voluntary National Standards** or **via a Regulatory Framework**, which encompasses different amount of Parts in different countries. As such, there is no unique solution for any challenges faced by third countries in the process of their national implementation, as the approach is strongly related to the national regulatory system and its specificities. However, the examples of implementation in the EU MS can be considered as good practices, supporting the successful implementation of the Eurocodes in third countries.

As it has already been highlighted, the **Eurocodes are a full system of design rules.** It is thus important for the National Authorities and other parties involved in their implementation to consider them as a complete system while restraining combination and mixed use with other existing codes or standards for the structural design of buildings and construction works.

The example of the non-EU Balkan countries highlights the noteworthy progress that has been achieved by all countries in the Balkan region in the adoption of the Eurocodes, since 2013. In the Balkan region, the **benefit of strengthened collaboration and information sharing among the countries** is evident, along with the positive effect of the support provided by neighboring EU countries and the European Commission. Projects and activities focused on building national capacities for the adoption and implementation of the Eurocodes have already been established with positive results. Such good practices need to continue and be further elaborated in the future, not only in the Balkan region but also in other regions.

It is also considered important for the countries willing to advance with the Eurocodes implementation to set a clear timeline for the future steps and actions, clearly identifying the resources needed in this process and assessing the stakeholders and institutions that can support the set actions in the timeline. The agreement in the actions by all stakeholder involved in this process is vital. Further, the Engineering Chambers and other regional engineering communities have also an important role to play in this process and can provide the necessary link with the practitioners. The involvement of practitioners is an important element, especially in cases they are already acquainted with the Eurocodes concepts and system and have accumulated experience in using the Eurocodes in their everyday practice.

The need for training activities, at national but also regional level has already been proven as a prerequisite for the successful adoption and implementation of the Eurocodes. Establishing regional platforms or "Communities of Practice" can further support advancing their implementation and facilitate users in the practical use. Such communities can also provide support towards the development and adoption of the Second Generation of the Eurocodes, expected to be published after 2021.

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