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THE FIRST GENERATION OF EN-EUROCODE 8: ITS STRENGTHS AND HOW IT CAN BETTER SERVE THE NEEDS OF PRACTICING ENGINEERS

Michael FARDIS[1]

Eight years have passed since the European Standardisation Committee (CEN) made available to the National Standardisation Bodies (NSBs) the suite of all 58 Structural Eurocodes, including the six parts of Eurocode 8. Since then, NSBs have adopted the Eurocodes as National Standards (normally after translation), developed and published their National Annexes and withdrawn conflicting National Standards (but not necessarily national structural design regulations conflicting with the Eurocodes). Even before enforcement of the EN-Eurocodes in all CEN countries as exclusive basis of structural design, the European Commission has issued a mandate to CEN for their revision, so that around 2020 they may evolve into the second generation of EN-Eurocodes. CEN has responded with a very detailed plan, specifying the needs of each Eurocode part for revision or extension of scope. After convergence of the European Commission and CEN on the details and terms of the evolution to the second generation, the process is expected to start before the end of 2014. Details of the evolution process and the context are given in Booth (2014), and are not repeated herein. Unlike (Booth 2014), which deals with a possible future third generation of Eurocode 8 after 2025, this paper focuses on the first generation as well as on the current emphasis on improving ease of use of the Eurocodes in the second generation, and how this may (or should) affect Eurocode 8, without compromising its current strengths. Only one third generation issue is addressed in the paper: sustainability.

The current strengths of EN-Eurocode 8

Eurocode 8 shares the strengths of the portfolio of Eurocodes: it belongs to a comprehensive, State-of-the-Art set of standards, meant to be seamlessly integrated and internally consistent, as well as user-friendly in the sense of sharing the same philosophy, following the same document structure and using common notation, terminology and methods. Moreover, the Eurocodes enjoy the stature of design standards of the largest and most populous economic entity in the developed world, and indeed the one which leads the world in structural engineering excellence, tradition and achievements. Therefore, they are in the best position to penetrate other parts of the present-day globalized world.

It is difficult to list specific strengths of Eurocode 8 without getting into technical details. So, only some general ones are highlighted here:

Eurocode 8 follows the most rational approach among all seismic design codes currently applied around the world. At the time it was written (in the early 2000s) it was closer to the State-of-the-Art than any of its contemporaries. Moreover, it provides plenty of flexibility:

1. It offers a range of analysis methods, from simple ones, such as the equivalent static approach, to the most advanced ones, like nonlinear response-history analysis;
2. It allows alternative combinations of design strength and ductility (Ductility Classes), without restrictions in their use; even two alternative types of concrete walls (ductile and large lightly reinforced ones) are foreseen within the same Ductility Class;
3. In addition to standard force-based design of new buildings or bridges using linear analysis

[1] Department of Civil Engineering, University of Patras, Patras, 26504, GREECE, fardis@upatras.gr

with a reduced response spectrum, Eurocode 8 includes a proto-displacement-based design option, with calculation of deformation demands via nonlinear analysis and their direct verification against deformation capacities;

4. Through the system of Nationally Determined Parameters (NDPs), it offers to countries the possibility to choose themselves the levels of protection (i.e., safety) and economy to be provided by Eurocode 8 designs. As a matter of fact, the recommended NDP values give very cost-effective designs, with a good balance of safety and economy.

There are weaknesses too:

a) The description of the seismic hazard is behind the State-of-the-Art: two parametrized sets of spectral shapes are provided for each one of the five standard soil types, anchored to a single ground motion parameter (the peak ground acceleration, from national zonation maps drawn for a single hazard level), allowing countries to choose the values of the parameters defining the shape. This results in large discrepancies across borders. Fortunately, the second generation of Eurocode 8 will incorporate a State-of-the-Art, harmonized description of the hazard in Europe, seamless across borders.

b) Certain techniques or technologies are missing from the scope: supplemental energy dissipation in buildings, flat-slab frames, post-tensioning of primary members, etc.

A general drawback of the Eurocodes is noted: being comprehensive, State-of-the-Art documents, the Eurocodes are powerful but demanding tools, more suitable for specialized structural designers and fairly large design offices than for individual practitioners working on a range of topics or types of projects. Mitigation efforts for the second generation are highlighted below.

Improving ease of use

Grassroots pressure from practice, especially from small SMEs or even individual professionals, has led to requests from European countries to improve ease of use in the second generation of EN-Eurocodes. This is understandable: the Eurocodes are certainly the most comprehensive and complete suite of State-of-the-Art structural design standards; however, completeness comes at the price of volume and apparent complexity. Besides, the first generation developed mostly from zero baseline and had not been thoroughly tested before in practice; so, teething problems were not unexpected.

In response, an advisory panel has been set up in CEN/TC250 "Structural Eurocodes" to prepare guidance to CEN/TC250, its Subcommittees and their Project Teams and all those involved in the technical preparation of the new ENs, on how to better serve ordinary practitioners, who need clear guidance for all common design cases; expert specialists, who want more freedom to innovate; clients; EU and national regulators, who need compliance with European regulations or directives, e.g., EU Directives 2004/18 and 2006/123 for Works and Services, the Construction Products Regulation (EU 2011), etc. Guiding principles have been drawn up; the top ten are (ranked by importance):

1. To improve clarity and understandability of technical provisions;
2. To improve accessibility to technical provisions and ease of navigation between them;
3. To include State-of-the-Art material, based on commonly accepted research results, validated through sufficient practical experience;
4. To avoid fundamental changes with respect to the design approach in the first-generation Eurocodes and their document structure (“evolution”, not “revolution”);
5. To improve consistency within and between the Eurocodes;
6. To improve consistency with standards for products and execution;
7. To provide clear guidance for all common design cases;
8. To limit the coverage of special cases, very rarely encountered by designers, to only general and basic technical provisions;
9. To ensure the freedom of expert practitioners to work from first principles and innovate;
10. To limit alternative application rules for the same situation.

Once the principles are agreed, Eurocode-specific examples may be developed on how to simplify the current text or provisions, reduce text length by avoiding repetitions and overlapping, omit well- known, text-book type of material, etc. A management structure may have to be set up to oversee the implementation, assess the outcome and put it to the test of practical application.

Concerning Eurocode 8, there is no question about the importance of principles of general applicability, namely no. 1, 2, 5 and 7 above; principle 6 is also important, in particular with regard to

anti-seismic devices. However, the exact implications of principles no. 3, 4, 8, 9 and 10 are not very clear. It will certainly be difficult to enrich the current provisions with alternatives, based on recent State-of-the-Art. In some cases, the range of alternatives currently provided in Eurocode 8 for the same situation may have to be reduced (e.g., three Ductility Classes for each one of the main construction materials, a wealth of analysis methods, two types of concrete walls of Ductility Class M: "ductile" and "large lightly reinforced" ones, etc). Adding new provisions will be possible only wherever the current EN has important gaps due to insufficient knowledge at the time it was written, when common structural systems or technological solutions are not treated (e.g., flat-slab frames, post-tensioned components in buildings, supplemental energy dissipation in buildings, etc), or, in general, when parts are incomplete and cannot be applied without adding the missing elements. Even then, to make room for the new provisions and the enlarged scope, a drastic reduction in the current text length may be needed (Part 1 of Eurocode 8 is by far the most voluminous of all 58 Eurocodes).

A third-generation issue: Sustainability

The EU has defined the role of the EN-Eurocodes as a means to comply with a number of important EU Directives: a) the Works Directive (EU Directive 2004/18) on contracts for public works, public supply and public service (covering procurement by public authorities of civil engineering and building works); b) the Services Directive (EU Directive 2006/123) on services in the Internal Market – covering public procurement of services; and c) the Construction Products Directive (89/106/EEC/1989, in short CPD), and more specifically its "Essential Requirements" 1, 2 and 4, on "mechanical resistance and stability", "safety in case of fire" and "safety in use", respectively. One can recognise "Essential Requirement" 2 as the rationale behind Parts 1-2 of EN 1991, 1992, 1993, 1994 and 1995; and "Essential Requirement" 1 as the basis of practically all other EN-Eurocode parts. The need for EN-Eurocodes to comply with these three "Essential Requirements" of the CPD was repeated in the EC's Mandate to CEN for the evolution to the second generation thereof. After the Mandate was issued, the CDP was upgraded to an act of the European Parliament and the European Council, in the form of the Construction Products Regulation EU/305/2011 (shortly CPR, EU 2011). In that process, "Basic Requirement" 7 was added, on the "sustainable use of natural resources". Because of timing, the new Requirement is not explicitly reflected in the structure of the Eurocodes suite agreed in the context of the response to the Mandate. However, the EC has already made clear its wish to have Sustainability better reflected in the second generation of EN-Eurocodes. In fact, a number of international bodies involved in standardisation, such as ISO TC59/SC 17 "Sustainability in buildings and civil engineering works", ISO TC71/SC 8 "Environmental management for concrete and concrete structures" and the International Federation for Structural Concrete (***fib***), have devoted to Sustainability a good part of their recent efforts and model products, such as the seminal ***fib*** Model Code 2010 and ISO standards 15392:2008, 21931-1:2010, 21929-1:2011, 13315-1:2012, 13315-2:2014, ISO/TS 12720:2014, etc.

The State-of-the-Art and international consensus on Sustainability in the construction sector are not ripe enough to support immediate full-fledged standardisation (parallel to Parts 1-2 of the five Eurocodes from EN 1991 to 1995, concerning "safety in case of fire"). Such developments may have to await the third generation of EN-Eurocodes. For Eurocode 8, this may mean emphasis on retrofitting and life-cycle aspects, structural kits allowing dismantlement and re-use, environmental impact calculations and optimisation of the global warming potential of materials and processes used in construction or of the life-cycle. This game changer of structural design is on its way.

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