On Possibility of Using Eurocode EN 1993 as Harmonized Standard

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Abstract. This article presents the content of Eurocode EN1993 and analyzes its application and the possibility of its use as a harmonized standard according to Federal Law No. 184 of 27.12.2002 On Technical Regulation.

1. Introduction
Steel structure design using Eurocodes stipulates for the use of the following regulations: Eurocode 3 (EN1993) \cite{1}, national parameters, EN1090 standard (building structure manufacturing, acceptance, and installation), EN standards, ISO standards, etc. (standards for steel, workpieces, and consumables).

2. Suggested solutions
The key provisions for calculations and design are set out in Eurocode 3 (EN1993) that comprises 20 parts. The legal document serving the same design purposes in Russia is the updated Rulebook 16.13330.2017 also known as the Rulebook on Steel Structures \cite{2}. One of the higher-tier technical regulations and rating documents in construction is the Technical Regulations on Safety \cite{3}, whose provisions facilitate the implementation of Federal Law No. 184 of 27.12.2002 On Technical Regulation \cite{4}. According to Federal Law No. 184, the implementation of the Technical Regulations on Safety is ensured through harmonized standards \cite{5}, i.e., the Eurocodes and (EN1993) in our case.

The Eurocode program was preceded by a decree of the European Commission on the approval and implementation of the construction program in 1975 pursuant to clause 95 of the Agreement. The goal of the program was to eliminate technical barriers in trade and harmonize technical requirements.

Within this program, the Commission took the initiative in creating a set of harmonized technical rules for the structural design that would initially serve as alternatives to the existing national standards in the member states and then replace them altogether.

The Commission together with the Steering Committee of member states had been developing the Eurocode program for 15 years, and the first generation of Eurocodes appeared in the 1980es.

In 1989, the Commission and the members of the European Union (EU) and the European Free Trade Association decided to prepare and issue Eurocodes through a number of mandates following Agreement 1 between the Commission and CEN to make them generic European standards (EN) in the future. This fact links the Eurocodes with the provisions of European Council directives and/or Commission decisions concerning the European standards (e.g. CE Directive 89/106/EEC on construction projects (CPD), and CE Directives 93/37/EEC, 92/50/EEC, and 89/440/EEC on public...
works and services, and other similar EFTA Directives aimed at the development of the internal market).

What are the Eurocodes? Eurocodes are regional model standards developed collectively by standardization authorities of the EU members. They are not designed to be used as-is and must be adapted to the local context. Thus, all the countries that use them develop their national appendices to Eurocodes that list parameters (specific values) for the given country and provide complementary explanations for inaccuracies due to the translation of the standard from English into the local language, the specifics of applications, etc. After adaptation, Eurocodes become optional standards (usually as national standards). The notation of the standard, in this case, receives a prefix corresponding to the national standardization authority, e.g. CH PK EN in Kazakhstan, DIN EN in Germany, etc.

The goals of Eurocodes:
• Providing generic design criteria and methods complying with the mechanical resistance, stability, and fire resistance requirements, including the durability and economy aspects;
• Providing a uniform understanding of structural design among owners, managers, designers, construction supply manufacturers, contractors, and operating organizations;
• Simplifying the exchange of services in construction between the member states;
• Simplifying the marketing and use of construction units and elements in member states;
• Simplifying the marketing and use of construction supplies and complement products whose properties are used in design calculations;
• Building a generic basis for research and development activities in the construction industry;
• Building the development basis for uniform design guidelines;
• Improving the competitive characteristics of European construction companies, contractors, designers, and structure and material manufacturers in the global market.

The construction Eurocodes consist of the standards listed in Table 1.

| Notation | Legal name | Title (Eng) | Title (Ru) | Number of parts |
|----------|------------|-------------|------------|-----------------|
| EN 1990  | Eurocode 0 | Basis of structural design | Основы проектирования несущих конструкций | 1 |
| EN 1991  | Eurocode 1 | Actions on structures | Воздействия на несущие конструкции | 10 |
| EN 1992  | Eurocode 2 | Design of concrete structures | Проектирование бетонных конструкций | 4 |
| EN 1993  | Eurocode 3 | Design of steel structures | Проектирование стальных конструкций | 20 |
| EN 1994  | Eurocode 4 | Design of composite steel and concrete structures | Проектирование композитных сталебетонных конструкций | 3 |
| EN 1995  | Eurocode 5 | Design of timber structures | Проектирование деревянных конструкций | 3 |
| EN 1996  | Eurocode 6 | Design of masonry structures | Проектирование каменных конструкций | 4 |
The key difference between the Eurocodes and the Rulebook is shown in Table 2.

Table 2. The key difference between the Eurocodes and the Rulebook.

| Eurocodes | Rulebook |
|-----------|----------|
| European standards are based on the parametric rating method that stipulates rating the final consumer properties only. | The rulebook regulations are based on the prescriptive rating method sets out the requirements to design, examination, construction, installation, etc. |
| Eurocodes are generic technical documents that do not specify processing techniques and solutions but present unified calculation models and rated parameter lists. These parameters are determined independently in every country in national appendices. | Rulebooks are documents that specify construction technologies, i.e., what should be built and how it should be built. They contain directly recommended parameters and engineering techniques to achieve them, which helps satisfy all of the requirements. |

The structure analysis of Eurocode 1993 for Steel Structures is presented in Table 3.

Table 3. The structure of Eurocode 1993 for Steel Structures.

| Design | Steel bridges |
|--------|---------------|
| Generic rules and building rules | Towers, pylons, and smokestacks |
| Generic rules for structural design with consideration of fire impact | Bunkers, reservoirs, and pipelines |
| Generic rules. Complementary rules for cold-formed elements and profiled sheets | Stilts and cut-off walls |
| Generic rules. Complementary rules for inox steel | Support structures for cranes |
| Elements of sheet steel structures | |
| Enclosure durability and stability | |
| Transverse load calculation for steel plate structures | |
| Joints calculation | |
| Fatigue strength | |
| Material toughness and mechanical properties across the sheet | |
| EN 1993 complementary rules for steel grades up to S700 | |
Eurocode 3 is used in steel structure design for buildings and civil engineering facilities. It complies with the principles and technical requirements for safety and operation, as well as the bases of their development and calculation set out in EN 1990 on the Bases of Structural Design.

Eurocode 3 comprises only the requirements for the load-carrying capacity, operability, durability, and fire resistance of steel structures. Other requirements, e.g., the ones concerning thermal and acoustic insulations, are not considered.

3. Experiment

Consider the calculations for a central strut with a durability test for the cross-section selected.

**EXAMPLE Load-carrying capacity and durability test for central struts.**

1) Source data.

An H-beam integral column (305×305×97 UKC, see Figure 1) is loaded with central compression force \( N = N_{Ed} = 2850 \, kN \). The column flexibility \( \bar{\lambda} \leq 0.2 \) and ratio \( \frac{N_{Ed}}{N_{cr}} \leq 0.04 \) (the ratio of the calculated axial force value and the critical force value for the respective instability mode in the elastic stage depending on the gross cross-section parameters).

Material: S275 steel, EN 10025-2 compliant. According to Table 3.1, EN 1993-1-1 for nominal element thickness \( t \leq 40 \, mm \), we have a nominal liquid limit value \( f_y = 275 \, N/mm^2 \), and the nominal tension strength limit \( f_u = 430 \, N/mm^2 \).

![Figure 1. The geometric properties of the H-beam section (305×305×97) made of EN 10025-2:2003 steel.](image)

- height \( h = 307.9 \, mm \)
- width \( b = 305.3 \, mm \)
- wall thickness \( t_w = 15.2 \, mm \)
- flange thickness \( t_f = 15.4 \, mm \)
- radius at bend \( R = 15.2 \, mm \)
- straight wall section height \( d = 246.7 \, mm \)
- cross-section area \( A = 12,300 \, mm^2 \)

The calculated load-carrying capacity of the cross-section under uniform compression \( N_{c,Rd} \) for different cross-section classes shall be determined according to the following formulae:

\[
N_{c,Rd} = \frac{A f_y}{\gamma_{M0}} \quad for \ classes \ 1,2,3;
\]  \hspace{1cm} (1)

\[
N_{c,Rd} = \frac{A_{ef} f_y}{\gamma_{M0}} \quad for \ classes \ 4;
\]  \hspace{1cm} (2)

where:
- \( A_{ef} \) – effective area of cross – section
- \( \gamma_{M0} \) – For S275 steel

2) Section class determination

Section class determination shall comply with EN 1993-1-1.

The ratio of the height and thickness of the straight part of the compressed H-beam wall.

\[
\frac{d}{t_w} = \frac{246.7}{15.2} = 16.2 < 33 \cdot \varepsilon = 33 \times 0.92 = 30.36;
\]  \hspace{1cm} (3)

where:
- \( \varepsilon \) is the coefficient depending on \( f_u \);
- with this ratio of section dimensions, the H-beam wall is classified as Class 1.
The ratio of H-cap width and thickness:
$$\frac{b_{ef}}{t_f} = \frac{130}{15.4} = 8.4 > 9 \cdot \varepsilon = 9 \times 0.92 = 8.28; \text{ but less than } 10 \cdot \varepsilon = 10 \times 0.92 = 9.2; \quad (4)$$

With this ratio of flange overhang and H-cap dimensions, the H-beam wall is classified as Class 2.

With these section parameters, the H-beam (305×305×97 UKC) is classified as Class 2 (in line with the least class of the section components, see EN 1993-1-1).

3) Load-carrying capacity strength check

The partial safety factor for the material (see. EN 1993-1-1):
$$\gamma_{M0} = 1.0.$$ 

The calculated load-carrying capacity of the Class 2 cross-section for uniform compression durability:
$$N_{c,Rd} = \frac{A \cdot f_y}{\gamma_{M0}} = \frac{12300 \times 275}{1.0} \times 10^{-3} = 3383 \text{ kN}; \quad (5)$$

where:
- $f_y$ is the EN 1993-1-1 liquid limit;
- $\gamma_{M0}$ is the EN 1993-1-1 partial safety factor;
- $A$ is the cross-section area.

Condition testing:
$$\frac{N_{Ed}}{N_{c,Rd}} = \frac{2850}{3383} = 0.84 < 1.0; \quad (6)$$

The durability condition is met.

Provide a calculation algorithm for load-carrying capacity for cross-section durability of central struts, see Figure 2.

Figure 2. The algorithm for checking the load-carrying capacity and durability test for central struts.

The EN1993 cross-section classification is shown in Figure 3.
4. Conclusions
To sum up the aforementioned, we can list the main differences between Eurocode 3 (EN1993) and Rulebook 16.13330.2017, aka the Rulebook on Steel Structures:
1. The detailed calculation principles for thin-walled, cold-formed, and roll-formed profiles.
2. Metal structure design principles for inox steels.
3. Metal structure calculation taking into account the fire resistance and fire safety.
4. Presence of semirigid joints and their consideration in calculations.
5. Metal structure calculation taking into account the test results.
6. The introduction of cross-section class notions
7. Impact strength calculation features for pieces with acute stress points.
8. Durability consideration and the loss of metal cross-section due to corrosion.
9. Features of accounting for various types of loads.
10. Features of calculating steel resistance,
11. The presence of detailed complementary sections on special structure design (pylons, towers, pipelines, reservoirs, bunkers, bridges, sheet piling, crane structures).
12. The key difference is that Eurocodes give designers more freedom than the Rulebooks because the European Union uses the parametric rating method, while the Rulebooks rely on the prescriptive method. This allows employing innovative solutions, brand-new technologies, and materials in the structure design.

5. References
[1] EN 1993, Eurocode 3. Design of steel structures.
[2] SP 16.13330.2017 “Set of rules. Steel structures ”
[3] Federal Law "Technical regulations on the safety of buildings and structures" No. 384 dated 30.12.2009
[4] Federal Law "On Technical Regulation" No. 184 of December 27, 2002
[5] Absimetov V E, Tusupbekov K M, Absimetov M V 2017 On the issue of reforming the system of technical regulation of the construction industry Collection of reports of the international scientific and practical conference “Science and innovations in construction” vol 1 (Belgorod)