Civil Engineering Beyond Limits 2 (2026) 11117

Civil Engineering Beyond Limits

journal home: www.acapublishing.com/journals/1/cebel

Research Article

Implications of Eurocode 3 and AISC 360 Design Approaches for Stability-Critical Steel Members

Elif Ağcakoca[1,*], Zeynep Yaman [1,2], Sebghatullah Jueyendah[1], Joseph Doucke Kahudi Omende[1]

[1]Department of Civil Engineering, Sakarya University, Esentepe Campus, 6 Serdivan, Sakarya, 54050, Turkey

[2]A International Vision University Engineering Faculty Civil Engineering Department Gostivar North, Macedonia

Keywords

Eurocode 3,
AISC 360-22,
Buckling curves,
Imperfection factor,
Steel flexural members,
Stability-critical members,
Cross-section classification,
Steel compression members,
LRFD vs partial safety factors,
Lateral–torsional buckling (LTB).

Abstract

This study presents a comparative evaluation of Eurocode 3 (EN 1993-1-1) and ANSI/AISC 360 regarding design requirements for steel elements subjected to axial load and combined axial-bending compression. Especially for thin-walled rectangular section elements, the transition from Class 3 to Class 4 in Eurocode 3 completely alters the design outcome and even reverses the regulatory framework for Eurocode 3 and AISC section sizing. The behavior of steel elements is examined from theoretical, analytical, and code-based perspectives, considering section classification as well as local buckling, global instability, and lateral-torsional buckling conditions. For flexural behavior and LTB (lateral–torsional buckling), open I-sections are considered. Closed RHS members are assessed only under axial compression for stability-critical behavior. For the representative thin steel column (KL/r = 128), Eurocode 3 predicts a design buckling resistance slightly higher than AISC 360 when the section is treated as Class 3 (0.61 MN vs. 0.59 MN); however, when Class 4 behavior is correctly accounted for through the effective section approach, the Eurocode 3 resistance drops to 0.19 MN, highlighting that cross-section classification can be as influential as the chosen design standard for stability-critical members.

1. Introduction

Steel is particularly preferred in high-rise buildings and wide-span systems due to its high strength-to-weight ratio, high ductility, and ease of assembly [1]. The safety, economy, and sustainability of steel structural systems depend on the calculation principles according to the limit state specified in the standards used by different countries. Columns under compression or beams under bending in frame systems that make up steel structures are the primary load-bearing elements in ensuring correct load transfer and overall system stability. The behavior of beam elements under bending is mostly determined by local buckling and lateral-torsional buckling mechanisms. In the behavior of compression elements under normal force, the system behavior is determined more by global buckling. It is known that residual stresses due to geometric defects are quite decisive in the behavior of steel elements under pressure[2]. In the construction of steel structures, generally two main standards are used in the world and in our country. EN 1993-1-1 (Eurocode 3) is used in European countries, and ANSI/AISC 360 is used in America, although there are differences in each state [3]. In Turkey, while regulation selection can be made on a project-specific basis, both regulations can be used in practice in the design of some special structures. One of the main reasons for conducting this study is that the use of both regulations is allowed optionally in our country. Therefore, in the design of structures, it is necessary to understand the standards not only in terms of numerical results but also in terms of design philosophy, safety approach and calculation logic, and to choose a regulation that will not compromise the safety of the structure suitable for the project [4]. While both standards calculate the element strength according to the limit state, the design can contain significant differences, especially when stability, initial defects and residual stresses are present in the element[5]. AISC 360 uses a simpler design that simplifies implementation. For example, the use of a single buckling curve for columns and the preference for a linear model divided into three regions for bending strength of beams make this regulation more useful[6]. Eurocode 3, on the other hand, considers the cross-sectional geometry and manufacturing method as part of the design in steel elements. This necessitates calculations for different buckling curves and element defect effects, cross-sectional type, and manufacturing-related variables[7]. The approach also differs in beams under bending effects according to both regulations. AISC 360 relies largely on experimental data in the evaluation of lateral torsional buckling. Eurocode 3, however, considers bending behavior more in the framework of element slenderness originating from the element cross-section[8]. In terms of the cross-sectional properties of the element, Eurocode 3 classifies cross-sections into four classes according to their plastic deformation capacity. AISC 360, on the other hand, performs its calculations by dividing the cross-sections into three separate regions: compact, semi-compact, and slender [9]. In both regulations, material quality and modulus of elasticity are influential in the separation of regions. These differences, along with the strength and safety factors used in both standards (ϕ in AISC 360, γM in Eurocode 3), directly affect the determination of element capacities and overall design efficiency [6]. Previous studies have shown that the most significant differences between Eurocode 3 and AISC 360 are particularly evident in elements with medium and high slenderness, controlled by stability, and that the main reason for this is the difference between the Direct Analysis Method and defect-based design approaches [10]. Despite this, comprehensive studies that consider both compression and bending elements together, based on these two standards, appear to be limited. Accordingly, in this study, Eurocode 3 (EN 1993-1-1) and AISC 360-22 are systematically compared specifically for steel elements under compression and bending effects. The study evaluates in detail the effects of buckling formulations, lateral-torsional buckling strength, and safety factors on structural safety and design effectiveness. In determining the strength of elements under compression, in addition to global buckling formulations, cross-sectional classification is crucial in the stability design of thin steel elements. In Eurocode 3, the transition from Class 3 to Class 4 activates the concept of effective cross-section and can alter the fundamental resistance mechanism of the element by taking into account the pre-yielding local buckling. Therefore, this distinction is quite important for thin-walled rectangular

*Corresponding Author: elifd@sakarya.edu.tr
Received 30 Jan 2026; Revised 06 Feb 2026; Accepted 06 Feb 2026

https://doi.org/10.36937/cebel.2026.11117
2687-5756 /© 2022 The Authors, Published by ACA Publishing; a trademark of ACADEMY Ltd. All rights reserved.

cross-section elements. In this article, to illustrate this situation, two different regulations for elements under compression are examined, and calculations are performed according to Class 3 and Class 4, which vary depending on the manufacturing method and other characteristics of the element.

2. Methodology

The structural capacity of steel elements is controlled by both general instability events and the local buckling response of component plate parts such as webs and flanges [11]. Eurocode 3 and AISC 360 calculate element strength by classifying steel sections according to plate slenderness criteria formed from element width-to-thickness ratios, thereby ensuring local stability. While both Eurocode 3 and AISC 360 provide fairly strict and similar provisions for compression and bending elements, they differ significantly in terms of fundamental design philosophies regarding section classification, plate slenderness limits, and especially local buckling behavior. For clarity and repeatability, the comparative methodology is organized as a systematic workflow encompassing section selection, material classes, boundary conditions, loading scenarios, and the relevant provisions of Eurocode 3 and AISC 360. In steel structural elements, lateral-torsional buckling, particularly in open-section beam elements with I-H-U geometry, constitutes a defining limiting condition in terms of bending behavior. In contrast, in RHS/SHS elements with closed geometry, stability under axial loading (compression-tension) is primarily determined by global bending buckling and local plate buckling (instability). Therefore, this article presents the differences between the two codes more clearly and strikingly, with bending behavior discussed using lateral I-geometry elements and buckling behavior discussed using RHS geometry elements. However, the numerical application in this study was performed using an element under compression. To clearly capture the effect of local buckling on the element under compressive load, the numerical application evaluated the same RHS element under both Class 3 and Class 4 assumptions in Eurocode 3 and compared it with the AISC 360-22 results for the same element. This approach aimed to provide a direct assessment of the impact of section classification and code-specific buckling formulations on the design strength.

2.1. Comparison of cross-section classification approaches in Eurocode 3 and AISC 360

According to the AISC 360-22 standard, steel sections are classified into three categories based on plate thickness criteria: compact, non-compact, and thin; this classification is based on width-to-thickness ratios, elastic modulus, and yield strength, which define the limits of the criteria. Short and thick compact sections can develop their full plastic resistance, while non-compact sections exhibit some yielding with limited rotational capacity, and thin sections are directly subject to local buckling. Resulting in a reduction of effective strength through the application of the Q factor [11]. Eurocode 3 (EN 1993-1-1) classifies steel sections into four classes based on local buckling behavior and plastic deformation capacity, using the parameter $\varepsilon = \sqrt{235/f_y}$. Classes 1 and 2 permit full plastic resistance, Class 3 is limited to elastic resistance, and Class 4 requires effective sections to account for local buckling.

$$\varepsilon = \sqrt{\frac{235}{f_y}} \tag{1}$$

Some criteria are considered in the classifications found in Eurocode 3. Class 1-2 allows for plastic behavior of the element. Class 3 limits the element's behavior under axial compression to elastic behavior. Class 4, on the other hand, reduces the strength effect by reducing the element cross-section by taking into account the local buckling that will occur in the element [12]. To clearly explain the information regarding the cross-section classes in Eurocode 3 and to make a brief comparison with AISC 360, it is necessary to better define the element properties. As the yield strength fy increases, the parameter ε decreases. This situation has made it necessary to examine the width/thickness limits of the element in Eurocode 3 in more detail. Therefore, especially in high-strength steels, the slenderness conditions of Eurocode 3 may be more conservative than those of AISC 360. Unlike AISC 360, which considers local buckling effects through strength reductions by taking tensile strength into account, Eurocode 3 mandates the definition of effective cross-sections for thin-section elements. This effect is particularly striking between class 3 and class 4 cross-sections. The difference in effective area between class 3 and class 4 can significantly reduce the design buckling resistance of the element. This becomes especially critical for RHS cross-sections; therefore, this cross-section was chosen under compressive load in this study.

2.2. Comparison of cross-section classification in AISC 360 and Eurocode 3

The biggest difference between AISC 360 and Eurocode 3 lies in the application of thin-section elements. The AISC 360 standard uses strength principles to determine the stress occurring in the element. Local buckling effects in the element are controlled by width/thickness limits (λ_p and λ_r), and sections are classified as compact, non-compact, or thin using a reduction factor (Q), Eurocode 3, on the other hand, determines element strength using a more geometry-based approach. The primary determining parameter in element geometry is the local buckling effect. The concept of effective section is incorporated into strength calculations to address local buckling[13].

Table 1. Comparison of Section Classification in AISC 360 and Eurocode 3

Aspect / Parameter	Eurocode 3 (EN 1993-1-1)	AISC 360 (LRFD, 2022)
Basis of classification	Plastic rotation capacity and ductility	Local stability limit states
Governing parameter	$\varepsilon = \sqrt{235/f_y}$	$\sqrt{E/f_y}$
Number of section classes	4 (Class 1–4)	3 (Compact, Noncompact, Slender)
Typical limiting criterion	e.g., $c/t \leq 9\varepsilon$(Class 1)	e.g., $b/t \leq 0.38\sqrt{E/f_y}$
Treatment of slender sections	Effective width / effective area approach	Strength reduction via Q-factor
Treatment of local buckling	Explicitly modeled through geometry	Indirectly considered through stress reduction
Design philosophy	Geometry-based and deformation-oriented	Stress-based and stability-oriented
Action–resistance evaluation	More detailed and theoretically refined	Relatively simple and computationally efficient

Eurocode 3 exhibits a pronounced reduction in resistance when transitioning from Class 2 to Class 3 sections, whereas AISC 360 introduces a more progressive strength reduction through linear interpolation. Eurocode 3 imposes increasingly restrictive slenderness limits with rising yield strength through the εparameter, whereas AISC 360 is governed mainly by the E/f_yratio, resulting in more conservative resistance predictions for high-strength, thin-walled, or welded sections [14]. Eurocode 3 controls local buckling in high-strength steels by reducing allowable width-to-thickness ratios through the εparameter, whereas AISC 360 employs stress-based slenderness limits (λ_p and λ_r) to classify elements and apply corresponding strength reductions.

3. Results and Discussion

In steel elements carrying axial loads, the global buckling of the system mechanism is determined. Therefore, Euler buckling theory will be used in calculations taking into account the dimensions of the element, support conditions and initial geometric defects [15]. Preventing local buckling in hot-rolled (a_0–d) design can lead to material waste as it is directly related to the section thickness of the element. The local buckling width-thickness limits of the AISC Specification are examined and the assumed local buckling coefficients are considered. Furthermore, this situation is applied in many regulations worldwide. In Eurocode, material quality is emphasized. Moreover, the Eurocode analysis method takes into account the level at which the loads are applied. In elements under bending effects, especially bending around the strong axis, lateral buckling occurs in the compression flange, showing a significant decrease in the system moment carrying capacity before the element reaches the plastic moment. AISC 360 (2022) can transition to a mechanism state with a single stress-based buckling relation that determines the strength of compression elements based on the critical buckling stress. In AISC 360 (2022), the element is classified between elastic and inelastic buckling regions according to the given slenderness limits. Eurocode 3, on the other hand, evaluates lateral-torsional buckling through slenderness coefficients derived from the relevant buckling curves, and performs element design with a defect-sensitive approach.

The nominal axial compressive resistance of a steel member is the maximum axial load governed by yielding and buckling effects.

$$P_n = F_{cr}A_g \tag{2}$$

where $F_{cr}$is the critical buckling stress and $A_g$is the gross cross-sectional area. The member slenderness is defined as

$$\lambda = \frac{L_c}{r} \tag{3}$$

The transition between inelastic and elastic buckling occurs at a specified slenderness limit

$$\lambda = 4.71\sqrt{\frac{E}{F_y}} \tag{4}$$

For inelastic buckling $\left(\lambda \leq 4.71\sqrt{E/F_y}\right)$,

$$F_{cr} = 0.658^{F_y/F_e}F_y \tag{5}$$

For elastic buckling $\left(\lambda > 4.71\sqrt{E/F_y}\right)$,

$$F_{cr} = 0.877F_e \tag{6}$$

where $F_e$is the Euler elastic buckling stress.

Eurocode 3 (EN 1993-1-1)
The design lateral–torsional buckling resistance is expressed as

$$M_{b,Rd} = \frac{\chi_{LT}W_yf_y}{\gamma_{M1}} \tag{7}$$

where $\chi_{LT}$is the lateral–torsional buckling reduction factor obtained from the relevant buckling curve, $W_y$is the section modulus, $f_y$is the yield strength, and $\gamma_{M1}$is the partial safety factor accounting for stability effects.

3.1. Comparative assessment of stability and LTB design approaches

AISC 360 incorporates boundary condition effects through the effective length factor $K$and adopts a simplified, design-oriented approach to global stability and lateral–torsional buckling, characterized by a three-region linear formulation based on the unbraced length. In contrast, Eurocode 3 uses critical buckling lengths combined with imperfection-based reduction factors that account for geometric imperfections, residual stresses, and moment gradients, resulting in a more detailed yet computationally intensive design framework.

Table 2. Key Differences Between AISC 360 and Eurocode 3 in Global Buckling Design Approaches

Parameter	AISC 360	Eurocode 3 (EN 1993-1-1)
Number of Buckling Models	Single general buckling curve	Five distinct buckling curves (a0, a, b, c, d)
Level of Sensitivity	Moderate, generalized design approach	High, cross-section-specific design approach
Effect of Residual Stresses	Considered indirectly through a constant reduction factor (0.877)	Incorporated directly through the selection of appropriate buckling curves
Design Approach	Practical and oriented toward rapid computation	More detailed and theoretically grounded analytical approach

Findings reported in the literature indicate that, for members with low slenderness, design provisions in AISC 360 generally result in less conservative resistance estimates than those obtained using Eurocode 3 [16]. Conversely, for members with greater slenderness, the use of calibrated buckling curves in Eurocode 3 has been demonstrated to yield more favorable and economically efficient resistance estimates. Findings reported in the literature indicate that, for members with low slenderness, the design provisions of AISC 360 generally lead to less conservative (higher) design resistance predictions, which in practice allow the selection of smaller cross-sectional sizes compared to those obtained using Eurocode 3 [16]. Conversely, as member slenderness increases, the use of calibrated buckling curves and imperfection-sensitive reduction models in Eurocode 3 may yield more economically efficient designs, in terms of higher usable design resistance and reduced required cross-sectional dimensions, for certain member types. However, this tendency is strongly dependent on the adopted cross-section class—particularly the distinction between Class 3 and Class 4 sections requiring effective properties—as well as the manufacturing method of the member.

3.2. Design safety and load–resistance factor frameworks

While both Eurocode 3 and AISC 360 require design resistance to exceed applied loads, they adopt distinctly different philosophies for incorporating uncertainty into design. AISC 360 adopts the Load and Resistance Factor Design (LRFD) framework, in which a resistance factor of $\phi_b = 0.90$is applied to the nominal flexural strength, together with factored load combinations such as $1.2D + 1.6L$. In contrast, Eurocode 3 adopts a partial safety factor methodology, assigning $\gamma_{M0} = 1.00$for cross-sectional resistance and $\gamma_{M1} = 1.00–1.10$ for stability verifications, in conjunction with factored load combinations such as $1.35G + 1.5Q$. AISC 360 addresses uncertainty mainly through resistance factors, whereas Eurocode 3 accounts for imperfections and slenderness effects using partial safety factors.

Eurocode 3 and AISC 360 adopt different cross-section classification systems, which govern the extent of plastic capacity development, susceptibility to local buckling, and the need for strength reduction, thereby leading to distinct practical design implications. As a result of differing classification rules, the same cross-section may yield different resistance predictions under Eurocode 3 and AISC 360, directly influencing member sizing and design efficiency. Both codes require sufficient resistance, but AISC 360 achieves reliability through calibrated resistance factors, whereas Eurocode 3 relies on partial safety factors that explicitly address instability in slender members.

After each key equation (e.g., P_n, F_{cr}, λ), define symbols immediately:

$$P_n = F_{cr} A_g \tag{8}$$

Where: Pn is the nominal axial resistance, Fcr is the critical buckling stress, Ag is the gross cross-sectional area, and Aeff is defines the effective cross-sectional area considered as load-bearing after local buckling in thin-walled (Class 4) sections.

3.2.1. Local buckling & effective section (Thin-walled members)

In thin-walled RHS/SHS elements, in addition to global element instability, local buckling can also be a determining factor in the carrier behavior. Eurocode 3 expresses this effect as the effective section approach (Aeff) defined in EN 1993-1-5, while AISC 360 evaluates this situation within a more integrated formulation. Therefore, when evaluated in terms of element stability, especially in critical thin-walled elements, EC3 often gives lower design values compared to AISC 360.

3.2.2. Reliability & Design Guidance

The partial safety factors and effective section assumptions in Eurocode 3 reflect the effects of local defects and plate slenderness in a sfer way in the design process. AISC 360, on the other hand, prioritizes calculation with ease of application in mind. When these two regulations are examined in this context, Eurocode 3 is preferred, especially for thin-walled and stability-critical elements where local buckling is a determining factor, while AISC 360 should be used for elements where local slenderness effects are not significant. However, in designs based on AISC 360, local buckling limitations must be carefully controlled.

Numerical Example: Axially Loaded Thin-Walled Stability-Critical Steel Column

Therefore, in this study, a Class 4 RHS steel column was evaluated according to both Eurocode 3 and AISC 360 standards to highlight the practical differences between thin-walled elements, which may be critical in terms of stability.

1-Geometry and assumptions

Section: RHS 250×150×6
Steel grade: S355
Gross cross-sectional area: Ag = 6000 mm²
Effective cross-sectional area: Aeff ≈ 1919 mm²
Radius of gyration: r ≈ 46.9 mm
Column length: L = 6.0 m
Boundary condition: Pinned–pinned (K = 1.0)
Elastic modulus: E = 210000 MPa

2.(a) Design According to Eurocode 3 (EN 1993-1-1)(CLASS 3)

Step 1: Slenderness ratio

$\lambda = L / r_\gamma$
$\lambda = 6000 / 46.9 = 128$

Step 2: Non-dimensional slenderness

$\bar{\lambda} = \lambda \cdot \sqrt{(f_\gamma / (\pi^2 E))}$
$\bar{\lambda} = 1.675$

Step 3: Buckling curve and imperfection factor

For rolled buckling about the minor axis → buckling curve b
Imperfection factor: $\alpha = 0.34$

Step 4: Reduction factor

$\varphi = 0.5 \cdot [\, 1 + \alpha\,(\bar{\lambda} - 0.2) + \bar{\lambda}^2]$
$\chi = 1 / [\, \varphi + \sqrt{(\varphi^2 - \bar{\lambda}^2)}]$
$\chi = 0.285$

Step 5: Design buckling resistance

N_β, Rd = $\chi \cdot A \cdot f_\gamma / \gamma M1$
N_β, Rd = 0.285 × 6000 × 355 = 0.61 MN

EN 1993-1-1 (Table 5.2) classifies RHS faces in axial compression as internal elements. For S355, $\varepsilon = \sqrt{(235/355)} = 0.814$ and the Class 3 limit is c/t ≤ 42ε = 34.17. Using c = b − 2t − 2r_i, RHS 250×150×6 satisfies Class 3 provided r_i ≥ 16.5 mm; hence, no effective section reduction is required.

2.(b) Design According to Eurocode 3 (EN 1993-1-1)

Step 1: Slenderness ratio (CLASS 4)

$\lambda = L / r_\gamma$
$\lambda = 6000 / 46.9 = 128$

Step 2: Non-dimensional slenderness

$\bar{\lambda} = \lambda \cdot \sqrt{(f_\gamma / (\pi^2 E))}$
$\bar{\lambda} = 1.675$

Step 3: Buckling curve and imperfection factor

For rolled buckling about the minor axis → buckling curve b
Imperfection factor: $\alpha = 0.34$

Step 4: Reduction factor

$\varphi = 0.5 \cdot [\, 1 + \alpha\,(\bar{\lambda} - 0.2) + \bar{\lambda}^2]$
$\chi = 1 / [\, \varphi + \sqrt{(\varphi^2 - \bar{\lambda}^2)}]$
$\chi = 0.285$

Step 5: Design buckling resistance

N_β, Rd = $\chi \cdot A \cdot f_\gamma / \gamma M1$
N_β, Rd = 0.285 × 1919 × 355 = 0.19 MN

3. Design According to AISC 360-22 (LRFD)

Step 1: Slenderness parameter

$K\,L / r_\gamma = 6000 / 46.9 = 128$

Step 2: Euler elastic buckling stress

$F_e = \pi^2 E / (K\,L / r_\gamma)^2$
$F_e = 126.3$ MPa

Step 3: Critical buckling stress

Since $F_e \leq 0.44 F_\gamma$, elastic buckling governs
$Fcr = 0.877\, F_e$
$Fcr = 110.8$ MPa
Step 4: Design compressive strength
$\varphi P_n = \varphi \cdot A \cdot Fcr$
$\varphi P_n = 0.9 \times 6000 \times 110.8 = 0.59$ MN

4. Comparison of Results

Eurocode 3 design buckling resistance: 0.61 MN (Class 3)

Eurocode 3 design buckling resistance: 0.19 MN (Class 4)

AISC 360-22 design compressive strength: 0.59 MN

This example clearly shows that the predicted buckling resistance of an axially loaded RHS member is strongly governed by cross-section classification. If the section is classified as Class 3, no effective-section reduction is required and the gross area is used, giving Nb,Rd ≈ 0.61 MN. However, once the same section is recognized as Class 4, local buckling must be accounted for through the effective section approach; therefore, even with an unchanged global reduction factor χ, the loss of effective area lowers the resistance to Nb,Rd ≈ 0.19 MN. In practical terms, this means that for thin-walled RHS/SHS members, the assigned section class can decisively influence both the required member size and the resulting design capacity.

The results show that the cross-section classification significantly affects the design buckling resistance. While Eurocode 3 predicts a resistance of 0.61 MN when considered as Class 3 for the element under investigation, the recognition of Class 4 behavior reduces the resistance to 0.19 MN due to the effective cross-section approach. A striking result is obtained when this value is compared with the AISC 360-22 estimate (0.59 MN). When the RHS member is treated as Class 3, Eurocode 3 and AISC 360-22 provide comparable design strengths (0.61 MN vs. 0.59 MN); however, once Class 4 behavior is considered via the effective section approach, the Eurocode 3 resistance decreases markedly to 0.19 MN, becoming substantially lower than the AISC prediction. This situation underlines the importance of cross-section manufacturing assumptions as well as the chosen design standard for thin-walled elements that are critical for stability.

5. Discussion and implications

Although Eurocode 3 and AISC 360 regulations perform calculations according to Euler buckling theory, the design results are comparable for the Class 3 assumption; however, a pronounced divergence occurs when the member is treated as Class 4 and effective section properties are applied. This difference arises from different calibration and safety. This difference is a result of different calibration and safety philosophies based on the Euler formula but incorporated into different codes. The comparison shows us how different results can be obtained for stability-critical elements when considering the different regulations adopted. This shows that the chosen standard can significantly affect the estimated capacity and consequently the element sizing, especially in thin structure systems.

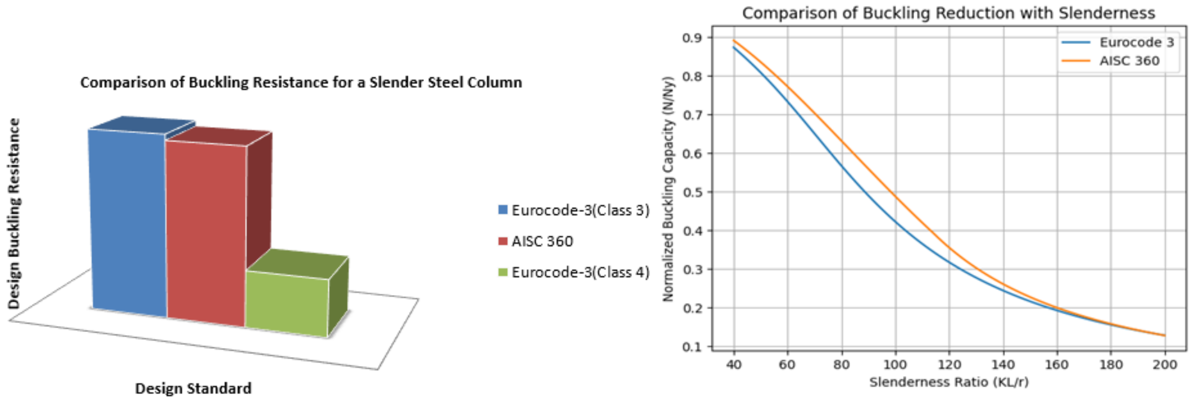

Figure 1. Effect of design standard and slenderness on the buckling resistance of stability-critical steel members according to Eurocode 3 and AISC 360

Figure 1 illustrates that Eurocode 3 and AISC 360-22 provide comparable buckling resistance for the member when treated as Class 3, whereas accounting for Class 4 behavior in Eurocode 3 leads to a pronounced reduction in resistance relative to AISC 360-22. For the current element (K L / ry = 128), the two standards use significantly different design methods. When treated as Class 3, Eurocode 3 and AISC 360-22 provide comparable resistances (0.61 MN vs. 0.59 MN); however, accounting for Class 4 behavior in Eurocode 3 reduces the resistance to 0.19 MN, substantially below the AISC prediction. Examining the difference between the two regulations shows that element thickness is effective, and that different calibration and safety philosophies are embedded in the regulations. In particular, Eurocode 3 uses buckling curves and defect factors, and thus defects are taken into account, while AISC 360 uses the elastic buckling method for such elements. Overall, this figure has shown that code selection can significantly influence the load-bearing capacity and, consequently, the element sizing in evaluating the behavior of stability-sensitive column elements.

6. Conclusion

This study investigates the behavior of steel elements with cross-sections determined by us under compressive and bending effects, and the impact of manufacturing choices on cross-section design, by comparing them within the framework of Eurocode 3 (EN 1993-1-1) and AISC 360-22. Bending behavior is addressed in the study using I-geometric elements, and detailed numerical comparisons are performed using RHS columns; this approach was chosen to more clearly highlight the differences between Eurocode 3 and AISC 360. In the examined example, although both standards adhere to the same formulation principles, it was found that the design compressive strengths differed significantly due to the way buckling behavior is handled and the differences in these standards.

When the member is treated as Class 3, Eurocode 3 and AISC 360-22 provide comparable design strengths (0.61 MN vs. 0.59 MN), reflecting their respective calibrated reduction and elastic-buckling formulations. Eurocode 3 yields comparable or slightly higher resistance when the section is treated as Class 3, whereas once Class 4 behavior is correctly accounted for, the design resistance becomes lower than that predicted by AISC 360. Both standards examined in this study aim to ensure adequate structural safety. In structures, particularly in thin and stability-critical elements such as purlins and facade belts, local or global buckling is crucial for structural safety. Therefore, the adoption of different regulations in different countries is not merely a matter of administrative preference, but also has vital implications for element sizing. Future studies could examine the buckling approaches in different regulations used in structures for different cross-section types [17].

Table 3. Summary Comparison Between AISC 360-22 and Eurocode 3

Parameter	AISC 360-22	Eurocode 3 (EN 1993-1-1)
Primary Approach	Simplified, practice-oriented	Detailed, cross-section–sensitive
Buckling Curve	Single curve	Five distinct curves (a0–d)
Computational Effort	Low, suitable for hand calculations	High, software support recommended
Global Analysis Approach	Direct Analysis Method (DAM)	Second-order analysis with imperfections

Declaration of Conflict of Interests

The authors declare that there is no conflict of interest.

References

[1.] Mengesha, G., Revolutionary Steel Structures: A Comprehensive Review of Current Trends and Future Directions. International Journal of Emerging Science and Engineering (IJESE), 2024.

[2.] Galambos, T.V. and A.E. Surovek, Structural stability of steel: concepts and applications for structural engineers. 2008.

[3.] Koh, H., Augmenting Steel Design with Data-driven and Advanced Analysis Approaches. 2022: The University of Wisconsin-Madison.

[4.] Da Silva, L.S., R. Simões, and H. Gervásio, Design of steel structures: eurocode 3: design of steel structures, part 1-1: general rules and rules for buildings. 2012: John Wiley & Sons.

[5.] De Biasi, R., Simulations techniques for lattice structure design. 2024.

[6.] Şahin, S., A comparative study of AISC-360 and Eurocode 3 strength limit states. 2009, Middle East Technical University (Turkey).

[7.] Temple, M.C. and G.M. Elmahdy, Slenderness ratio of main members between interconnectors of built-up compression members. Canadian Journal of Civil Engineering, 1996. 23(6): p. 1295–1304.

[8.] Bernuzzi, C. and B. Cordova, Structural steel design to Eurocode 3 and AISC specifications. 2016: John Wiley & Sons.

[9.] Maier, C., et al., Cross-sectional research: A critical perspective, use cases, and recommendations for IS research. 2023, Elsevier. p. 102625.

[10.] Topkaya, C. and S. Şahin, A comparative study of AISC-360 and EC3 strength limit states. International journal of steel Structures, 2011. 11(1): p. 13–27.

[11.] Hu, H.-S., et al., Local buckling of steel plates in composite members with tie bars under axial compression. Engineering Structures, 2020. 205: p. 110097.

[12.] Mashaly, H., et al., Evaluation of local-plate buckling coefficient for the design of cold-formed steel-lipped channel cross sections: Numerical simulations and design recommendations. Advanced Steel Construction, 2024. 20(1): p. 30–38.

[13.] Anwar, N. and F.A. Najam, Structural cross sections: analysis and design. 2016: Butterworth-Heinemann.

[14.] Costanzo, S., M. D'Aniello, and R. Landolfo, Seismic design criteria for chevron CBFs: European vs North American codes (part-1). Journal of constructional steel research, 2017. 135: p. 83–96.

[15.] Karim, F., Lateral torsional buckling of steel beams with beam and shell elements. 2024.

[16.] Mert, H. and O.C. Celik, A comparative study on steel-concrete composite columns for use in RC Tall Buildings in Seismic Areas. ce/papers, 2023. 6(3-4): p. 287–292.

[17.] Kövesdi, B., M.Z. Haffar, and S. Ádány, Buckling resistance of longitudinally stiffened plates: Eurocode-based design for column-like and interactive behavior of plates with closed-section stiffeners. Thin-Walled Structures, 2021. 159: p. 107266.

How to Cite This Article

Ağcakoca, E., Yaman, Z., Jueyendah, S., and Omende, J. D. K., Implications of Eurocode 3 and AISC 360 Design Approaches for Stability-Critical Steel Members, Civil Engineering Beyond Limits, 2(2026),11117.
https://doi.org/10.36937/cebel.2026.11117