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Comparative Analysis of Steel Component Section Classification and Local Buckling Design Methods in Chinese, European, and American Codes

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ABSTRACT

In order to guarantee structural efficiency and safety, structural steel design codes offer guidelines for the classification of steel sections and the evaluation of local buckling. Three major design codes are reviewed and compared in this paper: the Chinese Code for Design of Steel Structures (GB 50017), the American Institute of Steel Construction (AISC) Specifications, and the Eurocode (EN 1993-1-1). The methods used for section classification—which establishes the boundaries of cross-sectional slenderness—and local buckling standards—which have an impact on the ultimate strength and stability of steel members—are the main subjects of the comparison. Sections are classified into four classes by the Eurocode according to the width-to-thickness ratio of plate elements and their vulnerability to local buckling under compression. Class 1 (plastic sections) to Class 4 (slender sections) are the different classes in this hierarchy. A similar approach is used in the AISC Specifications, which classify sections as compact, non-compact, and slender and specify requirements for web and flange elements. The Chinese Code also makes use of a classification scheme, grouping sections according to the allowable limits for local buckling into categories for plastic, elastic, and semi-elastic materials. This paper examines how these codes differ in terms of safety factors, design philosophies, and residual stress treatment, as well as in the limits and calculation techniques for section classification. It also looks at how local buckling is handled when designing rolled and welded steel sections, discussing the significance of effective width concepts as well as the effects of local imperfections. The results show that although the codes share a common conceptual framework, there are notable variations in the numerical criteria and factors of safety that are applied. These differences may affect the selection of materials and cross-sectional dimensions, resulting in differences in design outcomes. For researchers and practitioners worldwide, the comparative analysis offers insightful information that could lead to a better understanding and possible harmonization of design practices in structural steel engineering.

Keywords: Section Classification, Local Buckling, Steel Structures, Eurocode, AISC, Chinese Code, Structural Engineering.

Introduction

Steel members are essential elements of contemporary architecture, frequently utilized in structures like bridges, buildings, and other infrastructure because of their adaptability, strength, and durability. These members can be beams, columns, trusses, or girders, each of which has a distinct structural function. International and national standards control the design and application of steel members, guaranteeing that they fulfill safety and performance criteria. When designing with steel, engineers need to take into account a number of important aspects, including the material's properties, its ability to support weight, and possible failure modes like yielding and buckling.

The classification of cross-sections is a crucial component of steel member design because it establishes how the members will behave under various loading scenarios. Engineers can evaluate the possibility of local buckling, a failure mode in which a member's thin-walled sections distort before the section as a whole yields, with the aid of this classification. Engineers are able to design steel structures that are not only strong and effective but also safe and dependable for the duration of their service life by following established codes and standards, such as the Chinese code, AISC code, and Eurocode.

It is essential to structural engineers to comprehend how steel members behave under different loading scenarios. The classification of sections and the occurrence of local buckling are two important factors. Section classification is the process of grouping steel cross-sections according to how easily they can buckle locally under various stress conditions. When portions of a cross-section, like flanges or webs, buckle locally without the member failing as a whole, this is known as local buckling.

Fig.1 Steel Structure

Eurocode (EN 1993-1-1)

Section Classification: The Eurocode classifies steel sections into four classes (Class 1 to Class 4) based on their ability to form plastic hinges and their susceptibility to local buckling:

- **Class 1 (Plastic):** Sections can develop plastic hinges and undergo significant rotation without reduction in load-carrying capacity.
- **Class 2 (Compact):** Sections can form plastic hinges but have limited rotation capacity before local buckling.
- **Class 3 (Semi-Compact):** Sections can attain the yield stress across the section but local buckling prevents the formation of a plastic hinge.
- **Class 4 (Slender):** Sections where local buckling occurs before the section reaches yield stress.

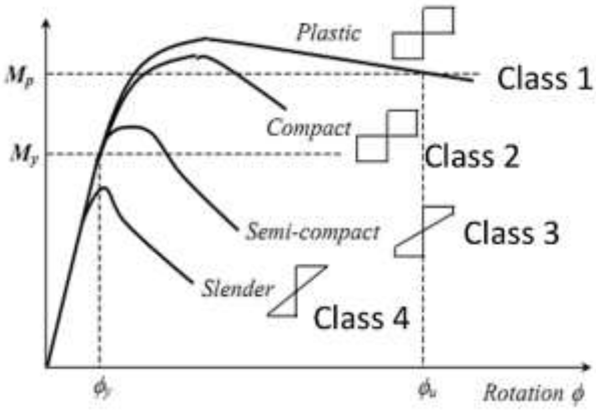

Fig. 2(a) : Cross Section classification

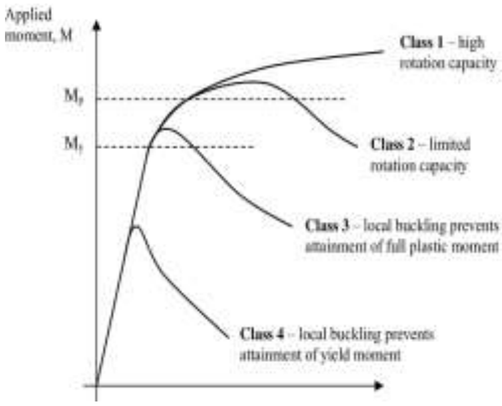

Fig. 2(b): Cross Section classification

Local Buckling: In order to prevent local buckling, Eurocode offers guidelines for calculating the limiting width-to-thickness ratios for various cross-sectional elements (such as flanges and webs). In order to account for local buckling, the code additionally provides reduction factors for the strength of thin sections.

US Code (AISC - American Institute of Steel Construction)

Section Classification: The AISC categorizes sections similarly into three types:

- **Compact Sections:** These sections can develop a full plastic moment and undergo significant rotation. The width-to-thickness ratios are controlled to avoid local buckling.
- **Non-Compact Sections:** Sections that can achieve yield stress in compression but are limited by local buckling before reaching the plastic moment.
- **Slender Sections:** Sections that experience local buckling at stresses less than the yield stress.

Local Buckling: The AISC specification provides criteria for calculating the width-to-thickness limits for different elements (flanges, webs) of the cross-section to ensure local buckling is prevented. These limits are based on the type of element and the nature of the applied stress (compression, bending).

Chinese Code (GB 50017-2017)

Section Classification: The Chinese code classifies sections similarly to Eurocode and AISC but with its own parameters:

- **Class A (Plastic):** Sections capable of developing a full plastic moment with large rotational capacity.
- **Class B (Compact):** Sections that can reach the plastic moment with limited rotational capacity.
- **Class C (Non-Compact):** Sections limited by local buckling before reaching the plastic moment.
- **Class D (Slender):** Sections where local buckling occurs before reaching the yield stress.

Key characteristics and aspects of local buckling in steel structures include:

i. Slenderness Ratio: Local buckling is more likely to occur in members with a high slenderness ratio, which is the ratio of the member's length to its width or depth. Members that are slender relative to their cross-sectional dimensions are more susceptible to buckling.

ii. Critical Load: There is a critical load, known as the buckling load or critical buckling load, at which local buckling initiates. When the applied compressive load reaches or exceeds this critical load, the member can buckle locally.

iii. Elastic and Plastic Buckling: Local buckling can occur in both elastic and plastic modes. In elastic buckling, the member returns to its original shape once the load is removed. In plastic buckling, the deformation becomes permanent even after the load is removed.

iv. Buckling Modes: Local buckling can take different forms depending on the member's cross-sectional shape and boundary conditions. Common buckling modes include flexural, torsional, lateral-torsional, and flexural-torsional buckling.

v. Effective Width: Engineers calculate an effective width for the cross-section of the member undergoing local buckling. This effective width represents the portion of the cross-section that is participating in resisting the buckling, and it is used in design calculations.

vi. Imperfections: Initial imperfections in the member, such as out-of-plumbness or out-of-straightness, play a significant role in local buckling. These imperfections can amplify the likelihood and severity of buckling.

vii. Mitigation Techniques: Engineers use various techniques to mitigate local buckling, such as increasing the section's dimensions, adding stiffeners or bracing, or using materials with higher yield strength. These measures help prevent or delay the onset of local buckling.

Theoretical background of local buckling in Chinese standards ,European standards and American standards:

An essential component of structural engineering is understanding the theoretical underpinnings of local buckling in steel structures. Slender components within a structural member, such as flanges or webs, can buckle on their own to cause local buckling, which can jeopardize the member's ability to support loads. Guidelines for preventing and accounting for local buckling are provided by Chinese, European, and American standards; however, they take distinct approaches to the issue in terms of safety considerations, design techniques, and classification.Below is a comparative analysis of the theoretical background of local buckling in these standards:

1. Section Classification

Chinese Standards (GB Standards)

- Classification Basis: The GB 50017-2017 standard classifies sections based on width-to-thickness (b/t) ratios into compact, non-compact, and slender categories.

- Purpose: This classification aims to determine the susceptibility of sections to local buckling and to apply corresponding design rules.

- Limits: Specific limits on b/t ratios are provided to ensure that the section's behavior is well-understood under various loading conditions.

European Standards (Eurocode)

- Classification Basis: Eurocode 3 (EN 1993-1-1) classifies sections into four classes (Class 1 to Class 4), based on their ability to form plastic hinges and resist local buckling before reaching ultimate strength.

- Purpose: The classification defines whether sections can reach plastic moments or are limited to elastic behavior before buckling.

- Limits: The limits on b/t ratios differ for each class, affecting the design approach, especially for Class 4 sections where local buckling is significant.

American Standards (AISC Standards)

- Classification Basis: AISC 360-16 categorizes sections as compact, non-compact, and slender based on b/t ratios.

- Purpose: The classification informs the design methodology, indicating whether local buckling must be explicitly considered and at what stage (before or after yielding).

- Limits: Similar to other standards, specific b/t ratio limits determine the classification, guiding the design and analysis process.

2. Design Approach and Methods

Chinese Standards (GB Standards)

- Design Methods: For slender sections, the GB standards require adjustments in design strength, calculated using empirical formulas that consider local buckling effects.

- Effective Width Method: This method reduces the cross-sectional area based on the effective width concept, accounting for reduced load-carrying capacity due to local buckling.

- Safety Factors: Specific safety factors and reduction coefficients are applied to account for uncertainties in material properties and loading conditions.

European Standards (Eurocode)

- Design Methods: Eurocode 3 employs an effective width method for Class 4 sections, reducing the effective cross-sectional area to account for local buckling. It also provides detailed rules for calculating critical buckling stress.

- Effective Width Method: The effective width is determined based on the slenderness of the plate elements, incorporating reduction factors that depend on the stress distribution and loading conditions.

- Partial Safety Factors: Eurocode employs partial safety factors for materials and loads, ensuring a consistent approach to safety and reliability.

American Standards (AISC Standards)

- Design Methods: AISC 360-16 provides explicit formulas for calculating the reduced strength of slender elements due to local buckling. The specification uses local buckling coefficients to adjust the critical stress for different loading and boundary conditions.

- Effective Width Method: Similar to Eurocode, the effective width method is used to account for reduced effective area in slender sections.

- Resistance Factors: AISC uses resistance factors to account for variances in material strengths and fabrication processes, ensuring adequate safety margins.

3. Critical Buckling Stress and Effective Width

Chinese Standards (GB Standards)

- Critical Buckling Stress: Calculated using empirical formulas considering material yield strength, geometric properties, and boundary conditions.

- Effective Width: Defined based on the reduction in the effective cross-sectional area due to local buckling, ensuring the design considers reduced capacity.

European Standards (Eurocode)

- Critical Buckling Stress: Determined using detailed analytical expressions considering the elastic modulus, Poisson's ratio, and geometric properties of the section.

- Effective Width: The effective width calculation includes factors that account for post-buckling strength and interaction with other elements.

American Standards (AISC Standards)

- Critical Buckling Stress: Formulas incorporate factors such as local buckling coefficients and material properties. The critical stress is adjusted based on the width-to-thickness ratio and boundary conditions.

- Effective Width: Applied in the same manner as in the Eurocode, where the effective width is used to determine the load-carrying capacity of slender sections.

Comparative Insights

1. Classification Consistency: All three standards classify sections based on their width-to-thickness ratios, although the terminology and specific limits differ. This classification directly influences the design rules applied.

2. Effective Width Method: Both Eurocode and AISC use the effective width method to account for the reduction in strength due to local buckling, while the GB standards also employ a similar approach with specific formulas.

3. Critical Buckling Stress Calculation: The methods for calculating critical buckling stress are broadly similar, relying on material properties and geometric factors, but the specific expressions and coefficients used can vary.

4. Safety and Resistance Factors: Eurocode and AISC use partial safety factors and resistance factors, respectively, to incorporate safety margins, while the GB standards have their own set of safety factors tailored to their specific design philosophy.

5. Regional Differences: While the core concepts are similar, reflecting the universal nature of local buckling phenomena, the specific guidelines, safety factors, and methods reflect regional engineering practices, construction materials, and regulatory environments.

Compare the design method of local buckling in Chinese standards ,European standards and American standards:

The design methods for addressing local buckling in steel structures differ across Chinese, European, and American standards. Each standard provides guidelines and methodologies tailored to its regional practices and safety philosophies. Here’s a comparative analysis of these design methods:

1. Chinese Standards (GB Standards)

Key Standard:

- GB 50017-2017: "Code for Design of Steel Structures"

Design Method for Local Buckling:

- Section Classification: Sections are categorized as compact, non-compact, or slender based on width-to-thickness (b/t) ratios. This classification determines the need to consider local buckling.

- Critical Buckling Stress Calculation: The standard provides formulas to calculate critical buckling stress, taking into account the material properties, geometric dimensions, and boundary conditions.

- Effective Width Method: For slender sections, where local buckling is a concern, the effective width method is used. This method involves reducing the effective cross-sectional area to account for the diminished load-carrying capacity due to local buckling.

- Strength Reduction: For sections classified as slender, the design strength is reduced by applying specific reduction factors or coefficients. These adjustments ensure that the section's capacity is not overestimated due to local buckling effects.

- Safety Factors: Specific safety factors are applied to account for uncertainties in material properties, construction quality, and loading conditions.

2. European Standards (Eurocode)

Key Standard:

- EN 1993-1-1 (Eurocode 3): "Design of Steel Structures – Part 1-1: General Rules and Rules for Buildings"

Design Method for Local Buckling:

- Section Classification: Eurocode 3 classifies sections into four classes (Class 1 to Class 4) based on their ability to undergo plastic deformation and the susceptibility to local buckling. Class 4 sections are particularly sensitive to local buckling.

- Critical Buckling Stress Calculation: The standard provides analytical expressions for determining critical buckling stress, considering the modulus of elasticity, Poisson's ratio, and geometric properties.

- Effective Width Method: For Class 4 sections, the effective width method is employed. This involves reducing the width of the plate elements that are effective in carrying loads. The reduced effective width is used to calculate the section's capacity, accounting for local buckling effects.

- Partial Safety Factors: Eurocode employs partial safety factors for materials and loads. These factors ensure that the design accounts for possible variations in material properties and uncertainties in load effects.

- Plate Buckling and Interaction Effects: Eurocode also considers interaction effects, such as the combination of shear and local buckling, especially in plated elements.

3. American Standards (AISC Standards)

Key Standard:

- AISC 360-16: "Specification for Structural Steel Buildings"

Design Method for Local Buckling:

- Section Classification: The AISC standard classifies sections as compact, non-compact, or slender based on their b/t ratios. This classification affects the design procedure and the consideration of local buckling.

- Critical Buckling Stress Calculation: AISC provides formulas to calculate critical buckling stress, incorporating local buckling coefficients that adjust for different boundary conditions and loading scenarios.

- Effective Width Method: Similar to Eurocode, the effective width method is applied for slender elements. The effective width is reduced to account for the effects of local buckling, thereby adjusting the strength calculations.

- Strength Reduction and Local Buckling Coefficients: The AISC standard uses local buckling coefficients to adjust the nominal strength of sections. These coefficients are derived from empirical data and theoretical models, ensuring that the reduced strength due to local buckling is accurately represented.

- Resistance Factors: AISC uses resistance factors in its design calculations to account for uncertainties in material strengths, fabrication processes, and load applications. These factors ensure a sufficient safety margin.

Comparative Analysis

1. Section Classification: All standards classify sections based on b/t ratios, influencing the design considerations for local buckling. The categories and specific limits differ slightly, reflecting regional differences in construction practices and safety requirements.

2. Effective Width Method: The effective width method is consistently used across all standards for handling slender sections prone to local buckling. The methodology involves reducing the cross-sectional area to reflect the reduced load-carrying capacity.

3. Critical Buckling Stress Calculation: Each standard provides specific formulas for calculating the critical buckling stress, considering material and geometric properties. The formulas and coefficients differ, tailored to each standard's empirical data and theoretical assumptions.

4. Strength Reduction Factors and Coefficients: Reduction factors or local buckling coefficients are used in all standards to adjust the design strength of slender sections. These factors ensure that local buckling effects are adequately accounted for in the design process.

5. Safety and Resistance Factors: Safety factors (in GB and Eurocode) and resistance factors (in AISC) are applied to account for uncertainties. These factors provide a safety margin to ensure the structural integrity under various conditions.

6. Regional Differences: While the underlying principles are similar, regional differences in empirical data, material properties, and construction practices lead to variations in the specific limits, coefficients, and safety factors used.

Comparison of section classification in Chinese standards, European standards & American standards:

All three codes (EC3, AISC LRFD, and GB 50017) classify sections based on their susceptibility to local buckling, which significantly impacts their load-carrying capacity. They consider geometric properties like width-to-thickness (b/t) and width-to-length (b/l) ratios for classification. Each code defines multiple classes with different resistance levels.

Table 1: Classification Features of Steel Codes [11,12,13]

Feature	EC3	AISC LRFD	GB 50017
Classification Basis	b/t and b/l ratios for flanges and webs	b/t ratio for flanges and webs (alternative methods exist)	b/t and b/l ratios for flanges and webs
Number of Classes	4 (Class 1-4)	3 (Compact, Non-compact, Slender)	4 (Class 1-4)
Focus	Primarily on ultimate limit state	Ultimate limit state and serviceability	Ultimate limit state
Additional Considerations	Plasticity and ductility indirectly considered	Includes second-order analysis requirements	No direct plasticity/ductility consideration

EC3 employs a system of four classes (1-4), with the most stringent limits for Class 1, which is least susceptible to buckling. It indirectly considers plasticity and ductility through member capacity calculations.

AISC LRFD uses three classes (Compact, Non-compact, and Slender) with separate criteria for flanges and webs. It also offers alternative methods like empirical equations for specific cases.

GB 50017 uses four classes similar to EC3, with distinct b/t and b/l limits, but does not directly address plasticity or ductility within its classification system.

Table 2: Section Classification Differences Among Codes [11,13,14]

Description	EC3	AISC	Chinese Code
Capable of achieving full plastic moment capacity while retaining significant rotation capacity	Class 1	Compact	Class 1
Can reach full plastic moment capacity but with limited rotation due to local buckling	Class 2	Class 2	Class 2
May experience local buckling before developing full plastic moment capacity	Class 3	Non-compact	Class 3
Local buckling occurs before reaching yield stress	Class 4	Slender	Class 4

The design process begins with calculating the design force, which involves understanding load factors and load combinations. These are specified differently across the Chinese, AISC, and EC3 codes. AISC provides definitions for load factors and combinations in its publications, incorporating factors like dead, live, wind, earthquake, rain, snow, and flood loads. AISC also addresses both ultimate limit states, ensuring safety and structural integrity, and serviceability limit states, maintaining usability and comfort.

EC3	AISC	Chinese Code
S235	A36	Q235
S275	A572 Gr.42	Q275
S355	A992	Q355

Table 3: Steel Grade Equivalencies [12,13,15]

EC3 and the Chinese code refer to structural components as "internal elements," while AISC uses "stiffened elements" for compression components along both longitudinal edges. Components attached along only one longitudinal edge are called "outside elements" or "outstands" in EC3 and the Chinese code, and "unstiffened elements" by AISC.

Design Code	Class 1	Class 2	Class 3
Eurocode 3 Part 1.1	$c/tf \leq 9\varepsilon$, $d/tw \leq 72\varepsilon$	$c/tf \leq 10\varepsilon$, $d/tw \leq 83\varepsilon$	$c/tf \leq 14\varepsilon$, $d/tw \leq 124\varepsilon$
AISC LRFD	$b/tf \leq 11\varepsilon$, $hw/tw \leq 110\varepsilon$	$b/tf \leq 18\varepsilon$, $hw/tw \leq 166\varepsilon$	-
GB50017	-	$b/tf \leq 13\varepsilon$, $hw/tw \leq 80\varepsilon$	-

Table 4: Limiting Width-to-Thickness Ratios for Welded I Sections [11,12,13]

Typically, the principal axis (x-x) aligns with the flanges, while the secondary axis (y-y) is perpendicular to the flange, and the z-z axis runs along the length of the member. However, in EC3, the y-y axis is designated as the major axis, parallel to the flanges, the z-z axis as the minor axis, perpendicular to the flange, and the x-x axis is aligned with the member's length.

According to the Chinese steel code, GB 50017-2017, the kind of structural member and the loading circumstances determine the permissible slenderness ratio for steel structures. The default permissible slenderness ratio for tension members is 300, while for compression members it is 150. Certain circumstances, like seismic forces, can modify these numbers. Depending on the seismic grade and member type, the code also specifies different slenderness ratios for different structural components under seismic conditions, such as frame columns and bracing systems.In contrast to

Table 5: Design Formulas for Columns in Bending and Axial Compression

Design Code	Column in Bending and Axial Compression Formula
AISC360	N/(χc fcr A) + (8/9) (Mx/(Zpx f) + My/(Zpy f)) ≤ 1.0, N/(χc fcr A) ≥ 0.2 N/(2χc fcr A) + (Mx/(Zpx f) + My/(Zpy f)) ≤ 1.0, N/(χc fcr A) < 0.2
EC3	N/(χy f A/γM1) + Mx/(χLT Zex f/γM1) + 1.5 My/(Zpy f/γM1) ≤ 1.0
GB50017	N/(χx f A) + βmx Mx/(γx Zex(1 - 0.8N/NEx') f) + η βty My/(χby Zey f) ≤ 1.0 Where NEx' = π^2 E A/(1.1 λx^2)

EC3 and AISC, which do not place a maximum on slenderness for tension members, AISC suggests that the ideal slenderness ratio (L/r) should not surpass 300. Whereas EC3 only uses the LRFD technique, AISC uses both ASD and LRFD.

For load combinations, Eurocode 3 (EC3) utilizes different and more intricate equations and factors than the American Institute of Steel Construction (AISC), which uses the same formulas and factors. The three codes list comparable steel grades with the same strengths but different names. AISC has a higher capacity than EC3 because it employs a single reduction factor curve, whereas EC3 uses five different ones. This is a significant difference in compression member design. GB 50017-2017, the Chinese steel code, uses a method based on partial safety factors, not ASD (Allowable Stress Design) or LRFD (Load and Resistance Factor Design). While it shares similarities with both LRFD and ASD, it has key differences:

- **Nominal Values:** Uses nominal values for loads and material properties, unlike LRFD's characteristic values.
- **Partial Safety Factors:** Accounts for uncertainties using partial safety factors, not statistically calibrated like in LRFD, but ensuring safety.
- **Ultimate Limit State:** Focuses on the ultimate limit state for design, similar to LRFD, with separate sections for serviceability and fatigue, similar to ASD.
- **Factor Calibration:** LRFD factors are statistically calibrated for specific target probabilities of failure, while GB 50017 factors rely on engineering judgment and experience.
- **Design Philosophy:** LRFD explicitly considers the probability of failure, whereas GB 50017 focuses on adequate safety margins.
- **Code Structure:** LRFD integrates different materials and limit states into a unified framework, while GB 50017 separates different design aspects.

It is observed that the highest restrictions on the width-to-thickness ratio are placed by the AISC's seismically compact section (Class 1). On the other hand, EC3 sets the strictest limitations for Class 2 and Class 3. A section may be categorized differently under different codes due to code variations; for example, it may be classified as Class 1 under one code and Class 3 under another, which could result in significant differences in the calculated design moment capacities.

Local buckling of Chinese standards, European standards & American standards

Local buckling of Chinese standards:

Local buckling is an important consideration in the design of structural elements, and Chinese standards provide guidelines for addressing local buckling in various structural materials, including steel and concrete. Here's how Chinese standards address local buckling:

I. **GB 50017-2017: Code for Design of Steel Structures:** This standard, issued by the Ministry of Housing and Urban-Rural Development of the People's Republic of China, provides guidelines for the design of steel structures in China. Chapter 5 of this standard focuses on the stability of structural members, including the assessment of local buckling. It provides equations and design rules for assessing the local buckling resistance of various steel cross-sectional shapes.

II. **GB 50010-2010: Code for Design of Concrete Structures:** This Chinese standard addresses the design of concrete structures. While it primarily deals with concrete, it may indirectly impact local buckling considerations in composite structures where concrete and steel are combined. Local buckling of steel reinforcement bars (rebar) in concrete elements may be addressed to ensure the stability of these elements.

III. **GB 50011-2010: Code for Seismic Design of Buildings:** In seismic design, which is especially important in regions prone to earthquakes, local buckling considerations may be integrated into the design process to ensure that structural members can withstand seismic forces.

IV. **GB/T 11263-2010: Hot-rolled H and cut T section steel:** This standard specifies the dimensions, shape, weight, and tolerances of hot-rolled H and cut T section steel, which are commonly used in construction. Proper design of these sections takes local buckling into account.

Local buckling of European standards:

European standards, known as Eurocodes, provide comprehensive guidelines for the design and construction of buildings and civil engineering works in Europe. Here's how European standards address local buckling:

I. **Eurocode 3 (EN 1993) - Design of Steel Structures:** Eurocode 3 deals specifically with the design of steel structures. It includes several parts, and Part 1-1, titled "General Rules and Rules for Buildings," provides detailed guidance on local buckling.

a) Section 5 of Eurocode 3 focuses on the stability of structural members subjected to compression, which is directly related to local buckling. This section provides equations and design rules for assessing the local buckling resistance of various steel cross-sectional shapes, such as I-sections, channels, angles, and other profiles.

b) Annex B of Part 1-1 provides additional information on the assessment of local buckling, including practical design recommendations.

II. **Eurocode 4 (EN 1994) - Design of Composite Steel and Concrete Structures:** Eurocode 4 addresses the design of composite steel and concrete structures. It considers the behavior of steel sections that are part of composite members, and local buckling of these steel sections is a key consideration. Local buckling of steel plates and sections is discussed in Part 1-1 of Eurocode 4.

III. **Eurocode 9 (EN 1999) - Design of Aluminium Structures:** Eurocode 9 is dedicated to the design of aluminum structures, including aluminum alloys. Similar to Eurocode 3 for steel, it provides guidelines on local buckling for aluminum structural elements.

Local buckling of American standards:

In the United States, the American Institute of Steel Construction (AISC) provides guidance and standards for the design and construction of steel structures. The treatment of local buckling in American standards primarily pertains to steel structural elements. Here's how local buckling is addressed in American standards:

AISC 360 - Specification for Structural Steel Buildings: AISC 360 is the primary standard for the design of steel structures in the United States. It includes detailed provisions for the assessment and design of structural members, taking into account local buckling considerations.

a) Chapter E of AISC 360 deals specifically with the stability of structural members, including columns, beams, and compression members. It provides design equations and guidelines for assessing local buckling of various steel cross-sectional shapes, such as I-sections, channels, angles, and other profiles.

b) AISC 360 also includes provisions for calculating the slenderness ratios of members to determine whether they are susceptible to local buckling. The standard sets limits on these ratios to ensure the stability of the members.

AISC 341 - Seismic Provisions for Structural Steel Buildings: AISC 341 is a companion standard to AISC 360 and focuses on seismic design of steel structures. It includes provisions related to local buckling under seismic loading conditions, particularly for columns and beam-column connections.

AISC 310 - Specification for Design of Anchor Rods: AISC 310 addresses the design of anchor rods, which are essential components for anchoring steel structures to foundations. It includes provisions to ensure that anchor rods are designed to resist local buckling under axial loads.

Limitation of the codes

The primary problem with section classification is that webs and flanges' potential for interactive stabilization is overlooked when evaluating local buckling independently. Furthermore, although member slenderness plays a major role in member ductility, the classification process does not take this into consideration in relation to lateraltorsional buckling[17]. The classification table does not take boundary conditions, loading conditions, or material properties into account; it only takes geometric properties into account. Additional checks for particular member types or loading scenarios may be needed in the code. Like any design standard, the section classification system in Chinese code GB 50017 has some limitations, especially when it comes to section classification.

- The width-to-thickness ratios of flanges and webs, among other geometric characteristics, are the main basis for the classification criteria. When there are large variations in geometry along the length of the member, or when sections have non-standard shapes, this method might not adequately capture the complex interactions and local effects.

- The impact of load configurations and support conditions on the buckling behavior of sections is not directly considered in the classification. The classification itself is more generic and might not accurately represent the particular vulnerabilities of sections under particular loading or support scenarios, even though these factors are taken into account during the overall design process.

- Although the classification system divides sections into classes to account for local buckling, there are occasionally sharp transitions between these classes. The actual behavior of steel sections may be more gradual than the classification indicates, especially in the vicinity of the class boundaries, which could result in conservative designs.

- The simplified section classification may not apply directly to designs involving advanced analysis where the entire stress distribution and post-buckling strength are taken into account, or it may result in unduly conservative designs.

- Global stability problems like column buckling and lateral-torsional buckling, which call for extra inspections outside the purview of section classification, are not directly addressed by the classification system; instead, it only deals with local buckling and cross-sectional strength.

- Compared to EC3, it may lack nuance in classification for certain geometries.

- Limited recognition outside of china.

- Because of its all-encompassing and performance-driven methodology, EC3 is more widely accepted. In contrast to simpler systems, EC3 requires more computations and comprehension, which makes it more time-consuming; in contrast, AISC and GB50017 are more succinct. The "individual plate rule" is the classification methodology for cross-sections for all specifications. According to this rule, slender plate elements must be compared with the codified slenderness limits in order to determine the cross-sectional classification. These limitations take into account the stress patterns and edge support conditions (internal or external), but they do not take into account the way the plate elements that make up the section interact with one another. It is only comprehensive to determine categories for cross-sections under complex loading patterns when axial forces and bending around multiple axes are taken into account. However, a lot of guidelines only consider the cross-sections' geometric properties when classifying them, ignoring the effect of different loading conditions. The most obvious conclusion drawn from the codes is that, although the effects of stress gradients on flanges are taken into consideration by Eurocodes, all other specifications ignore the loading conditions related to weak-axis behavior.

There is no classification criterion in the Chinese Steel Design Code [11]. As opposed to AISC, which divides cross sections into three classes, EC3 separates cross sections into four distinct classes using three boundary lines. According to Eurocode 3, the buckling of the flange and web plates, which are subject to different restrictions, affects the flexural performance in I-shaped sections. This perspective is faulty, though, because the flanges and web constrain each other mutually. Consequently, it is crucial to take into consideration how the two buckling modes interact. The plastic-plastic approach requires lateral bracing at plastic hinges, as mentioned by EC3, but the maximum distance permitted is not specified.

However, when the plastic moment is used in the member design, AISC LRFD offers more precise guidance by recommending limits on slenderness to avoid lateral-torsional buckling[16, 18].

Advantages and Disadvantages of Chinese standards ,European standards and American standards:

The Chinese Code (GB 50017):

GB 50017, also known as the Chinese Code for Design of Steel Structures, provides numerous benefits in the field of steel structure design. An outstanding advantage of this product is its capacity to easily conform to the specific construction methods used in China, allowing for effortless incorporation of the country's engineering customs and materials. The use of the limit state design philosophy emphasises a comprehensive approach that gives equal importance to both serviceability and safety. Furthermore, GB 50017 offers a comprehensive approach to categorising sections, enabling a thorough comprehension of how sections behave under various types of loads.

Drawbacks: Although GB 50017 has its merits, it may provide difficulties for multinational projects due to the requirement for future customisation. It is important to carefully analyse the variations in design philosophy and local practices between China and other locations. The code's extensive scope, although beneficial, might also increase intricacy, potentially resulting in difficulties in real-world implementations.

The European Code, also known as Eurocode 3 - EN 1993:

Eurocode 3 (EN 1993) stands out for its uniformity across European nations, offering a cohesive approach to design principles and regulations. Implementing a performance-based approach enables a detailed evaluation of both the maximum load capacity and the ability to operate adequately, hence improving the dependability of structural systems. The modular composition of Eurocode 3 allows for customisation to meet unique project needs, promoting a versatile approach to steel design.

Drawbacks: Although Eurocode 3 has its merits, its modular structure might potentially complicate implementation, necessitating a comprehensive comprehension of the interaction among various components. Moreover, engineers who are shifting to Eurocode 3 can encounter a period of adjustment, particularly if they are used to alternative design principles.

The American Code (AISC):

The AISC guidelines, which regulate steel design in the United States, offer numerous benefits to the industry. The AISC requirements have a lengthy track record of practical use and rigorous examination, solidifying their status as a thoroughly tested and dependable set of guidelines. The widespread acceptance of AISC requirements enables easy customisation for worldwide applications with minimum adjustments. In addition, AISC offers a precise section categorization system that streamlines the design process by categorising sections into various groups based on their compactness, noncompactness, and thinness.

Drawbacks: Although AISC specifications enjoy international recognition, their design philosophy is predominantly influenced by domestic traditions in the United States. Adapting this specific method may necessitate modifications for projects in areas with distinct engineering customs. Some critics contend that AISC specifications may allocate less importance to specific design characteristics, such as serviceability, in comparison to other codes.

Conclusion

The study provides a comparative analysis of the steel design codes—GB 50017 (Chinese Code), Eurocode 3 (EC3), and the American Institute of Steel Construction (AISC) Specifications. The comparison highlights the distinctions in section classification, local buckling considerations, and safety factors. While all three codes aim to ensure the structural safety and efficiency of steel members, they exhibit differences in their approach to classification limits, the treatment of local buckling, and the application of safety factors. These differences are influenced by regional practices and empirical data, which affect design outcomes. Understanding these distinctions is crucial for engineers working on international projects to ensure compliance and optimize design according to the relevant standards.

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