| CHAPTER 1 |

Introduction to Structural Steelwork Design to HK Code 2011

- **Learning Objectives**

- Identifying different limit states for designing structural steelwork.
- Understanding the general applications of different types of structural steel members.
- Understanding the material properties of structural steel.
- Overview of the commonly used national and international design codes, including the Chinese National Standard (GB) and Eurocode.

1. Structural Steel Design

The design of steel structures is based primarily on the yield stress or proof stress of the steel but ductility and weldability are other important properties. Welded structures give a weight saving and ease of fabrication compared with bolted or riveted structures.

The main compositions of steel are :

Iron (about 98%)	Silicon (0.1 - 0.5%)
Carbon (max. 0.25%)	Sulphur (max. 0.05%)
Manganese (max. 1.6%)	Phosphorous (max. 0.05%)

Ductility and weldability deteriorate with increasing carbon content, while yield strength increases with carbon content. Hence the carbon content is limited to 0.25% in basic structural steel to give a compromise.

In BS EN 10025, grade of steel commonly used in construction are Grade S275, S355 and S460. Their nominal design strengths are 275, 355, 460 N/mm^2. The actual design strength depends on the thickness of the member. Steel is ductile at temperatures above 10°C and becomes more brittle as temperature falls.

Steel complying to Chinese Standard GB50017 is frequently used in Hong Kong and Mainland China. The steel grades are designated by Q235, Q345, Q390 and Q420.

Fatigue failure occurs in members subjected to fluctuating loads such as crane girders, bridges. Failure occurs through progressive growth of a crack. To avoid fatigue failure, design and detailing should be such that stress concentration and abrupt changes of section are avoided.

The atmospheric corrosion resistance of structural steel can be enhanced by:

- Protective coating of paint, aluminum and zinc. Metal coatings are more resistance to corrosion and abrasion resistant.
- Cathodic protection for structures continuously immersed in water.
- Some steel grades can be supplied with copper content which has improved corrosion resistance.
- Weathering steel which contains an increased amount of phosphorous, chromium and copper. Exposure to atmosphere causes the formation of a protective oxide film.

Structural steel performs badly in fires with the strength decreasing with increase in temperature. There are statutory requirements for fire protection and these lay down the fire resistance period that any load bearing element in a given building must have. They also give the fire resistance periods for different types of fire protection.

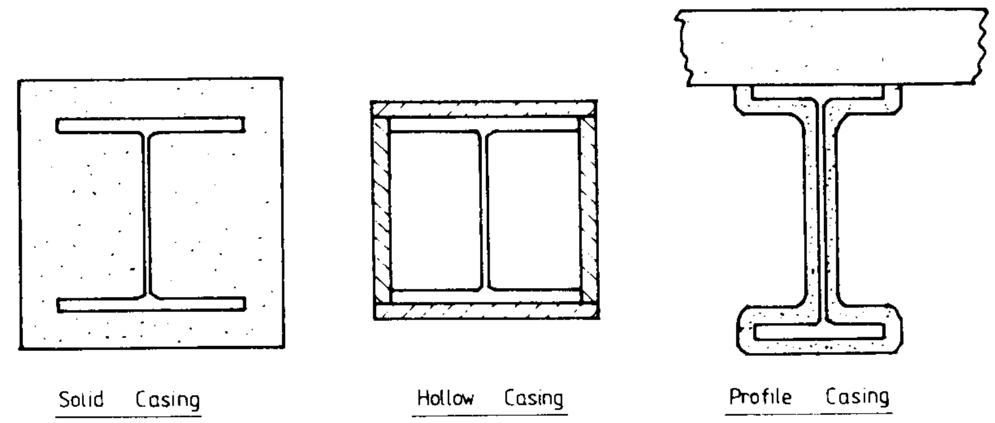


Figure 1 – Fire Protection of Steel Members (extracted from ref. 6)

1.1 Steel sections

1.1.1 Rolled and formed sections

They are produced in steel mills from steel billets by passing them through a series of rolls.

- ***Universal Beams*** (**UB**) are very efficient in resisting bending moment about major axis.
- ***Universal Columns*** (**UC**) are primarily used to resist axial load but may be used in resisting bending moments.
- ***Channels*** are used for beams, bracing members, truss members and in compound members.
- ***Equal and Unequal Angles*** are used for bracing members, truss members and for purlins and sheeting rails.
- ***Structural Tees*** are produced by cutting a Universal Beam or Column into two parts, and are used for truss members, ties and light beams.
- ***Circular, Square and Rectangular Hollow Sections*** are produced from flat plates. They are very efficient compression members, used in lattice girders, building frames and as purlins and sheeting rails.

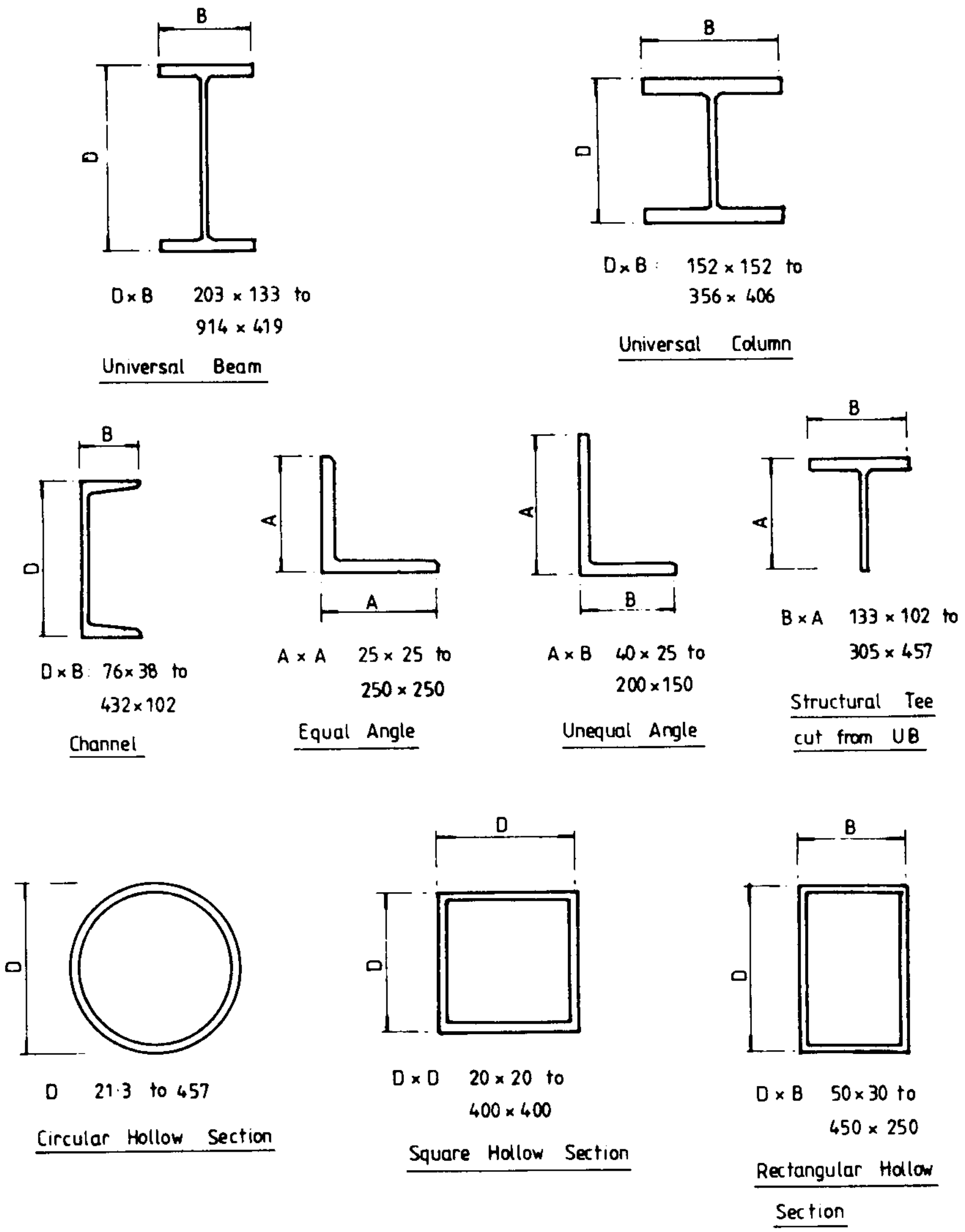


Figure 2 – Hot Rolled Steel Sections (extracted from ref. 6)

1.1.2 Built-up sections

They are made by welding plates together to form **I** (plate girders), **H** (built-up columns) or box members (box girders and box columns).

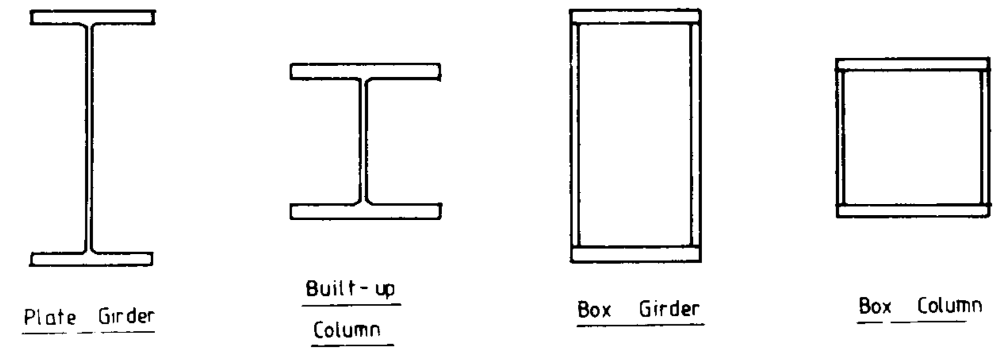


Figure 3 – Built-up Sections (extracted from ref. 6)

1.1.3 Compound sections

They are formed by

(i) strengthening a rolled section by welding on cover plates,
(ii) combining two separate rolled sections, e.g. crane girder,
(iii) connecting two members together to form a strong combined member. e.g. laced and battened members

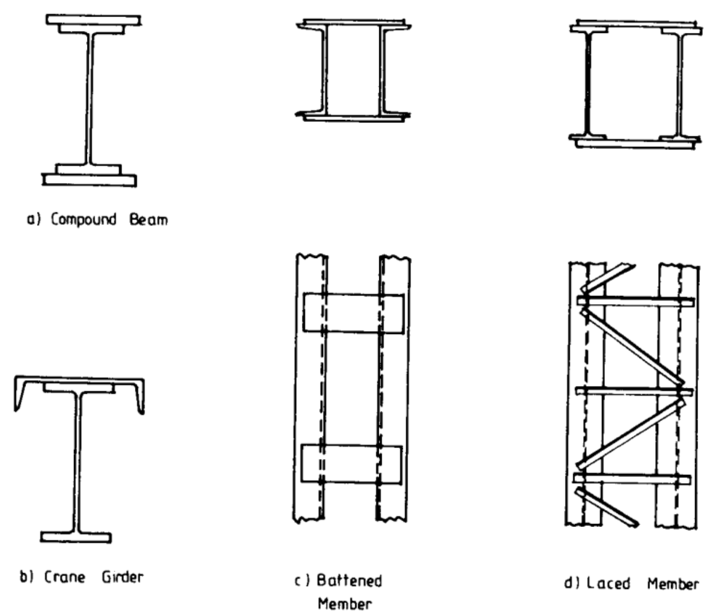


Figure 4 – Compound Sections (extracted from ref. 6)

1.1.4 Cold rolled sections

Thin steel plates can be formed into a wide range sections by cold rolling. These sections are used in purlins and sheeting rails in steel structures. Three common sections - the zed, sigma and lipped channel are shown.

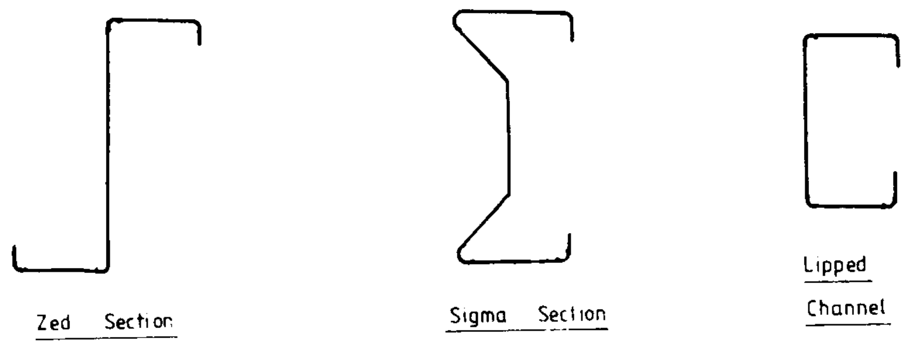


Figure 5 – Cold Rolled Sections (extracted from ref. 6)

2. HK Code of Practice for the Structural Use of Steel 2011

2.1 Introcution

A new ***Code of Practice for the Structural Use of Steel 2011*** (HK Code) is published by the Buildings Department of the Government of the HKSAR in **October 2011**. The design of structural steelwork of this course would make reference to this version of the HK Code.

The HK Code is based on limit state design principles and is similar to BS 5950:2000. Specified loads are multiplied by appropriate partial safety factors which represent the variability of the loading and inaccuracies in the design assumptions. The factored loads are then applied to the structure and the resulting load effects are then compared to the resistance of each member which is based on a proportion of the yield strength (yield strength is divided by a partial safety factor for material).

2.2 Limit State Design

Structures should be designed by considering the limit states at which they become unfit for their intended use. Appropriate load factors are used at each limit state so that the required level of safety and serviceability may properly be taken into account. Examples of limit states relevant to steel structures are listed in below. (Table 2.1 of the Code is extracted).

Table 2.1 - Limit states

Ultimate limit states (ULS)	Serviceability limit states (SLS)
Strength (including general yielding, rupture, buckling and forming a mechanism)	Deflection
Stability against overturning, sliding, uplift and sway stability	Vibration
Fire resistance	Wind induced oscillation
Brittle fracture and fracture caused by fatigue	Durability

Note:- For cold-formed steel, excessive local deformation is to be assessed under ultimate limit state.

Table 1 – Extract of Table 2.1 of HK Code[1]

Ultimate limit states (ULS) represent those limit states beyond which collapse of or irreparable damage to the structure may take place and a high load factor is used. ***Serviceability limit states (SLS)*** represent those limit states beyond which the structure becomes unfit for its intended use in service. In general the load factor used for SLS is unity.

Table 4.2 - Partial load factors and combinations for normal condition design

Load combination (including earth, water and temperature loading where present)	Load Type						
	Dead G_k		**Imposed** Q_k		**Earth and water** S_n	**Wind** W_k	**Temperature** T_k
	Adverse	Beneficial	Adverse	Beneficial			
1. dead and imposed	1.4	1.0	1.6	0	1.4	-	1.2
2. dead and lateral	1.4	1.0	-	-	1.4	1.4	1.2
3. dead, lateral and imposed	1.2	1.0	1.2	0	1.2	1.2	1.2

Table 2 – Extract of Table 4.2 of HK Code[1]

A summary of the partial safety factors for ultimate limit states below:

Table 4.4 - Summary of partial load factors for ultimate limit state

Type of load and load combination	Factor γ_f
Dead load, except as the following.	1.4
Dead load acting together with lateral load and imposed load combined.	1.2
Dead load acting together with crane loads and imposed load combined.	1.2
Dead load acting together with crane loads and lateral load combined.	1.2
Dead load acting together with extreme event load.	1.05
Dead load whenever it counteracts the effects of other normal loads.	1.0
Dead load when it counteracts extreme event load.	1.0
Dead load when restraining sliding, overturning or uplift.	1.0
Imposed load except as the following.	1.6
Imposed load acting together with wind load.	1.2
Imposed load acting together with extreme event load.	0.35
Wind load.	1.4
Extreme event load.	1.0
Wind load acting together with imposed load.	1.2
Storage tanks, including contents.	1.4
Storage tanks, empty, when restraining sliding, overturning or uplift.	1.0
Earth and ground water load, nominal values.	1.4
Earth and ground water load, acting beneficially.	$\leq$ 1.0
Exceptional snow load, for cold regions, caused by local drifting on roofs.	1.05
Forces caused by temperature change.	1.2
Forces caused by differential settlement.	1.4
Forces caused by differential settlement together with imposed and wind loads.	1.2
Vertical crane loads.	1.6
Vertical crane loads acting together with horizontal crane loads.	1.4
Horizontal crane loads from surge or crabbing, see clause 13.7.	1.6
Horizontal crane loads acting together with vertical crane loads.	1.4
Vertical crane loads acting together with imposed load.	1.4
Horizontal crane loads acting together with imposed load.	1.2
Imposed load acting together with vertical crane loads.	1.4
Imposed load acting together with horizontal crane loads.	1.2
Crane loads acting together with wind load.	1.2
Wind load acting together with crane loads.	1.2
Vertical crane loads acting beneficially to counteract other loads.	1.0

Notes: (a) "Wind" load includes minimum lateral load of 1.0% of dead load.
(b) Extreme event loads are treated as ultimate loads.

Table 3 – Extract of Table 4.4 of HK Code[1]

2.3 Methods of Design (Clause 2.1)

Within the overall concept of limit state design three basic methods of design are permitted which influence both the method of analysis and the final structural form. The three methods are:

2.3.1 Simple Design

The distribution of forces may be determined by assuming that members intersecting at a joint are pin connected. Joints should be assumed not to develop moments adversely affecting either the members or the structure as a whole.

2.3.2 Continuous Design

The connections are assumed to be capable of developing the strength and/or stiffness required by an analysis assuming full continuity. Both elastic and plastic analyses are included in this method.

2.3.3 Semi-continuous Design

Semi-continuous design may be used where the joints have some degree of strength and stiffness which is insufficient to develop full continuity. The moment capacity, rotational stiffness and rotation capacity of the joints shall be based on experimental evidence or advanced elasto-plastic analysis calibrated against tests. This method is more specialized than the other two and is seldom used in design office.

2.4 Methods of Analysis (Clause 6.1)

Second-order effects should be included in an analysis unless they can be proven to be insignificant. There are TWO types of ***P-delta*** effects namely ***P-Δ*** effect and ***P-δ*** effect. ***P-delta*** effects should be considered either in the analysis or in the design stage depending upon analysis method used.

Figure 6 (Extract of Figure 6.1 of HK Code[1]) illustrates the ***P-Δ*** and the ***P-δ*** effects in a structure. ***P-Δ*** effect is due to change of geometry of the structure, and ***P-δ*** effect is due to member curvature and change of member stiffness under load.

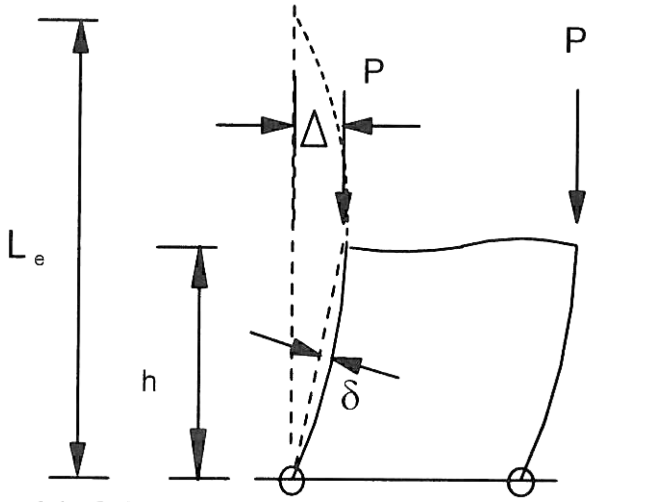


Figure 6.1 - Column effective length, P-Δ and P-δ moments

Figure 6 – Extract of Figure 6.1 of HK Code[1]

2.4.1 Simple Design

Lateral forces taken by linked rigid structure and beams are assumed simply supported on columns (details refer to clause 6.5 of the HK Code)

2.4.2 Fisrt-order Linear Elastic Analysis

Use the original and undeformed geometry of the structure for analysis (details refer to clause 6.6 of the HK Code). The ***P-Δ*** and the ***P-δ*** effects should be checked in the member design by the moment amplification and effective length methods.

2.4.3 Second-order Elastic P-Δ Only Analysis

Allow for the effects of deformation of the structure in the analysis (details refer to clause 6.7 of the HK Code). The effect of member bowing (***P-δ***) is not considered and should be allowed for separately.

2.4.4 Second-order Elastic P-Δ-δ Analysis

Allow for the effects of deformation of the structure and the bowing deflection of members (details refer to clause 6.8 of the HK Code). The method considers the followings.

- Equilibrium in the deformed position of the structure (i.e. ***P-Δ*** effect).
- Member bowing deflection and stiffness change (i.e. ***P-δ*** effect).
- Frame and member imperfections.

2.4.5 Advanced Analysis

Allow for the effect of deformation of the structure and members and material yielding (details refer to clause 6.9 of the HK Code)

Figure 7 summarizes different analysis methods to be used in structural steel design.

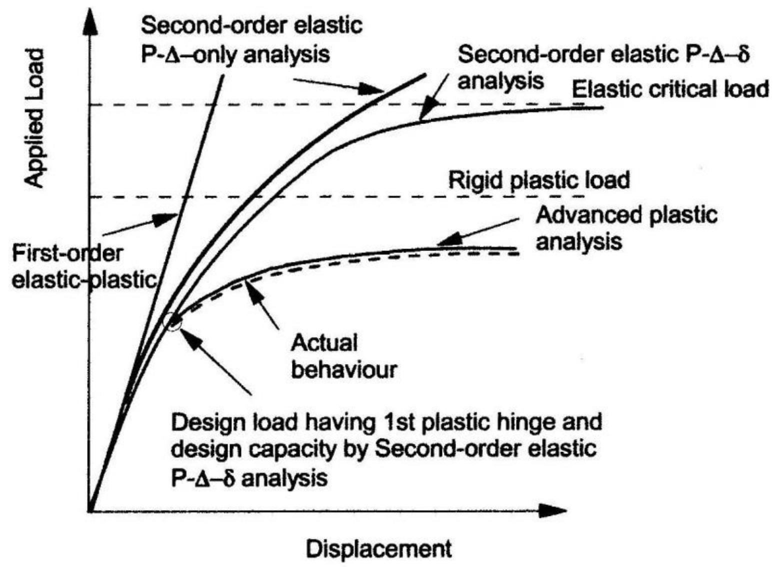


Figure 7 – Structural Analysis Methods (Extracted from ref. 7)

2.5 Imperfections (Clause 6.4)

Imperfections are due to geometrical and material effects and should be simulated by using suitable and equivalent geometrical imperfections. The effects of imperfections shall be taken into account when considering the following:

- Frame analysis
- Member design
- Bracing members

2.5.1 Frame Imperfections

The effects of imperfections for typical structures shall be incorporated in frame analysis using an equivalent geometric imperfection $\Delta = h/200$ or notional horizontal force approach (see Figure 8).

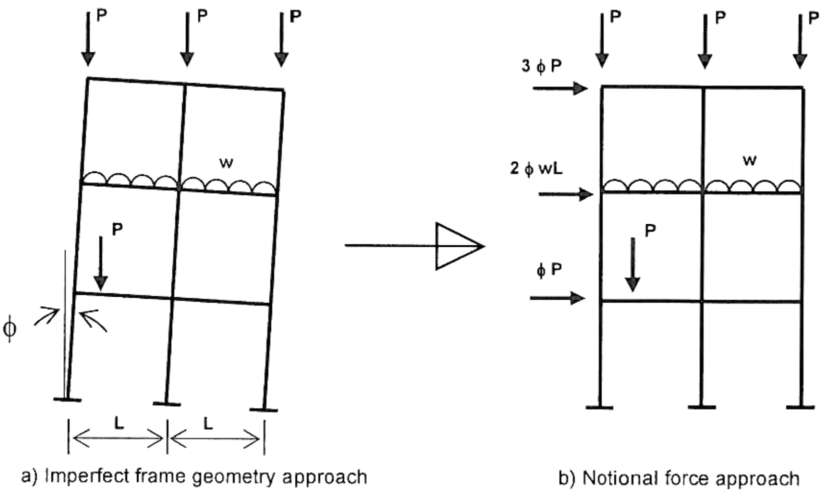


Figure 6.3 - Notional horizontal force for out-of-plumbness

Figure 8 – Extract of Figure 6.3 of HK Code[1]

2.5.2 Member Imperfections

For a compression member, the equivalent initial bow imperfection specified in Table 6.1 of HK Code may be used in ***second order analysis*** of the member. Alternatively, the effects of imperfections can be considered in member design when using ***the effective length method*** and the ***moment amplification method***.

Table 6.1 - Values of member initial bow imperfection used in design

Buckling curves referenced in Table 8.7	$\frac{e_0}{L}$ to be used in Second-order P-Δ-δ elastic analysis
a_0	1/550
a	1/500
b	1/400
c	1/300
d	1/200

Table 4 – Extract of Table 6.1 of HK Code[1]

2.6 Loading (Clause 2.5)

The loading to be used should be obtained from the appropriate standard. In general this requires the use of

- Code of Practice for Dead and Imposed Loads 2011
- Code of Practice on Wind Effects Hong Kong - 2004

The load factors to be applied are dependent on the limit state and combination of loading being considered.

At the ultimate limit state the values given in Table 4.2 of the code (see Table 2 of the handout) should be used. It will be seen that in general higher load factors are applied to imposed loads than to dead loads, the exceptions being combined loading situations in which it is unlikely that all the loads will reach their maximum values at the same time. It should be noted that where dead loads are required to restrain uplift or overturning, a load factor of unity is assumed. At the serviceability limit state the load factors are all taken as unity.

2.7 Ultimate Limit States (ULS) (Clause 2.3)

2.7.1 Strength (Clause 2.3.1)

The load carrying capacity of each member and connection, as determined by the relevant provisions of the HK Code, should be such that the factored loads would not cause failure.

2.7.2 Stability (Clause 2.3.2)

The Code recognizes both stability against overturning and sway stability.

Stability against overturning is usually provided by the dead load of the structure and/or foundations. Where this is not adequate a restraining system should be provided.

Resistance to horizontal forces should be provided using one or more of the following lateral load resisting systems: triangulated bracing; moment-resisting joint, shear walls; properly designed staircase enclosing walls, service and lift cores or similar vertical elements. Reversal of load direction should be considered in the design of these systems.

2.7.3 Fatigue (Clause 2.3.3)

Fatigue need not be considered unless a structure is subjected to numerous fluctuations of stress. Stress changes due to normal fluctuations in wind loading need not be considered. For fatigue design, refer to the relevant clauses of the code of practice.

2.7.4 Structural Integrity and Robustness (Clause 2.3.4)

The requirements of this clause ensure that all structures are considered as a whole and are sufficiently robust to resist loading not taken into account in the design. Where required by local or national regulations the structure should also be designed to localize or resist accidental damage.

The aim is to minimize the risk of localized damage causing progressive collapse, buildings should satisfy the following:

- Provision of tension continuity tying both vertically and horizontally.
- Resistance to minimum notional horizontal load.
- Withstanding removal of a vertical element by establishing alternative load paths to limit the extent of damage or collapse.
- Designing key elements.

The structure should be checked to ensure that removal of certain elements due to accidental damage will not cause collapse of more than a limited proportion of the structure. If a particular element cannot be removed without causing disproportionate collapse then it should be classed as a key element and designed accordingly.

In general, ties should be provided at each principal roof or floor level and be designed to resist a specified nominal tensile force. Where buildings are to be designed for accidental damage, the tensile load in the tie or beams should be increased by the use of formulae based on beams acting in catenary on the removal of an intermediate column. In addition column splices should be designed to resist a tensile force based on the load applied at the floor beneath the splice. This is in order to support, to some extent, the floor below the splice on the accidental removal of the column beneath that floor.

2.7.5 Brittle Fracture (Clause 2.3.5)

Brittle fracture can only occur in areas subject to applied tensile stress. The possibility of its occurrence is increased where there is

(a) Welding
(b) Stress concentration
(c) Rapid load application
(d) High stress
(e) Thick material
(f) Low temperature

The possibility of brittle fracture can be reduced by the selection of an appropriate steel quality and thickness depending on the circumstances. The risk of brittle fracture can be reduced even further by ensuring that welding is of a high standard.

2.8 Serviceability limit states (SLS) (Clause 2.4)

Serviceability limit states consider service requirements for a structure or structural element under ***normal applied loads***. Examples are *deflection, human induced vibration*, *wind induced oscillation* and *durability*.

2.8.1 Deflection (Clause 5.2)

Deflection limitations are given as advisory only thus recognizing that, in practice, deflection should be limited by the behavior of the structure and the serviceability requirements of the cladding and finishes.

Table 5.1 of HK Code gives recommended limitations for certain structural members and is extracted below. Generally the serviceability loads may be taken as the ***unfactored*** imposed loads.

Table 5.1 - Deflection limits

a)	*Deflection of profiled steel sheeting*	
	Vertical deflection during construction when the effects of ponding are not taken into account	Span/180 (but ≤20 mm)
	Vertical deflection during construction when the effects of ponding are taken into account	Span/130 (but ≤ 30 mm)
	Vertical deflection of roof cladding under dead and wind load	Span/90 (but ≤ 30 mm)
	Lateral deflection of wall cladding under wind load	Span/120 (but ≤ 30 mm)
b)	*Vertical deflection of composite slab*	
	Due to imposed load	Span/350 (but ≤20 mm)
	Due to the total load plus due to prop removal (if any) less due to self-weight of the slab	Span/250
c)	*Vertical deflection of beams due to imposed load*	
	Cantilevers	Length/180
	Beams carrying plaster or other brittle finish	Span/360
	Other beams (except purlins and sheeting rails)	Span/200
	Purlins and sheeting rails	To suit cladding
d)	*Horizontal deflection of columns due to imposed load and wind load*	
	Horizontal drift at topmost storey of buildings	Height/500
	Horizontal drift at top of a single storey portal not supporting human	To suit cladding
	Relative inter-storey drift	Storey height/400
	Columns in portal frame buildings	To suit cladding
	Columns supporting crane runways	To suit crane runway
e)	*Crane girders*	
	Vertical deflection due to static vertical wheel loads from overhead traveling cranes	Span/600
	Horizontal deflection (calculated on the top flange properties alone) due to horizontal crane loads	Span/500
f)	*Trusses*	
	Typical trusses not carrying brittle panels	Span/200

Note:
Exceedance of the above limit is not acceptable unless a full justification is provided.
Precamber deflection can be deduced in the deflection calculation.
Ponding should nevertheless be avoided in all cases.
Long span structures should be checked against vibration and oscillation.

Table 5 – Extract of Table 5.1 of HK Code[1]

2.9 Properties of Materials and Sections

2.9.1 Strength of steel (Clause 3.1.2)

The design strength of the steel (p_y) is given in Table 3.2 and Table 3.3 of the code for steel sections complying to BS EN 10025 and GB50017.

Table 3.2 - Design strength p_y for steels supplied in accordance with BS EN standards (plates, hot rolled sections, hot finished and cold formed hollow sections)

Steel grade	Thickness less than or equal to (mm)	Design strength p_y (N/mm^2)
S235	16	235
	40	225
	63	215
	80	215
	100	215
	150	205
S275	16	275
	40	265
	63	255
	80	245
	100	235
	150	225
S355	16	355
	40	345
	63	335
	80	325
	100	315
	150	295
S450	16	450
	40	430
	63	410
	80	390
	100	380
S460	16	460
	40	440
	63	430
	80	410
	100	400

Note that the thickness of the thickest element of the cross section should be used for strength classification of rolled sections.

Table 6 – Extract of Table 3.2 of HK Code[1]

Table 3.3 - Design strength p_y for steels supplied in accordance with Chinese standard GB50017 (plates, hot rolled sections, hot finished and cold formed hollow sections)

Steel grade	Thickness less than or equal to (mm)	Design strength p_y (N/mm^2)
Q235	16	215
	40	205
	60	200
	100	190
Q345	16	310
	35	295
	50	265
	100	250
Q390	16	350
	35	335
	50	315
	100	295
Q420	16	380
	35	360
	50	340
	100	325

Table 7 – Extract of Table 3.3 of HK Code[1]

2.10 Classification of cross sections (Clause 7.2)

In order to prevent local buckling of elements in compression, each element is classified as ***plastic, compact, semi-compact or slender*** depending on its depth (or width) to thickness ratio. This classification is carried out by reference to Table 7.1 of the Code. Cross-sections may be composed of elements of different classification, but, in general, the cross-section will be classified according to the lowest class of element which it contains. For example a section with compact flanges (class 2) and a semi-compact web (class 3) will be classified as a semi-compact cross-section.

Class 1 – Plastic cross sections are those in which all elements subject to compression comply with the values given in Table 7.1 for plastic elements. *Full plastic moment capacity* can be developed and *a plastic hinge can be developed* with sufficient rotation capacity to allow redistribution of moments within the structure. Only Class 1 sections may be used for *plastic design*.

Class 2 – Compact cross sections are those in which all elements subject to compression comply with the values given in Table 7.1 for compact elements. *Full plastic moment capacity* can be developed but *local buckling may prevent development of a plastic hinge* with sufficient rotation capacity to permit plastic design.

Class 3 – Semi-compact cross sections are those in which all elements subject to compression comply with the values given in Table 7.1 for semi-compact elements. The stress at the extreme fibers can reach the design strength but local buckling may prevent the development of the full plastic moment. It can develop elastic moment capacity only (i.e. $M_c = p_y * Z$).

Class 4 – Slender sections are those which contain slender elements subject to compression due to moment or axial load. Local buckling may prevent the stress in a slender section from reaching the design strength.

2.10.1 Limiting Proportions

Because the local buckling resistance is related to the geometrical width-to-thickness ratio, the limiting ratio at which it equals the design strength varies between grades of steel. For convenience *tabulated values are given for a design strength of 275 N/mm^2.* For any other design strength the ratio is adjusted using the ratio

$$\varepsilon = \sqrt{\frac{275}{p_y}}, \quad \text{see table 7.1 of the code.}$$

Table 7.1 of the code gives limiting proportion for various types of element. The entry "Web, with neutral axis at mid-depth" is relevant for a section with equal flanges subject to bending about the major axis. It is a special case of the next entry "Web, generally" which covers sections subject to bending and axial load and is also relevant for webs of sections with unequal flanges subject to bending only.

Table 7.1 - Limiting width-to-thickness ratios for sections other than CHS and RHS

Compression element				Ratio [a]	Limiting value [b]		
					Class 1 plastic	Class 2 compact	Class 3 semi-compact
Flange	Outstand element	Compression due to bending	Rolled section	b/T	9ε	10ε	15ε
			Welded section		8ε	9ε	13ε
		Axial compression		b/T	Not applicable		13ε
	Internal element	Compression due to bending		b/T	28ε	32ε	40ε
		Axial compression		b/T	Not applicable		
Web of an I-, H- or Box section [d]	Neutral axis at mid-depth			d/t	80ε	100ε	120ε
	Generally [c]	r_1 is negative		d/t	$\frac{80\varepsilon}{1+r_1}$ but $\geq 40\varepsilon$	$\frac{100\varepsilon}{1+r_1}$	$\frac{120\varepsilon}{1+2r_2}$ but $\geq 40\varepsilon$
		r_1 is positive		d/t		$\frac{100\varepsilon}{1+1.5r_1}$ but $\geq 40\varepsilon$	
	Axial compression [c]			d/t	Not applicable		
Web of a channel				d/t	40ε	40ε	40ε
Angle, compression due to bending (Both criteria should be satisfied)				b/t d/t	9ε 9ε	10ε 10ε	15ε 15ε
Single angle, or double angles with the components separated, axial compression (All three criteria should be satisfied)				b/t d/t $(b+d)/t$	Not applicable		15ε 15ε 24ε
Outstand leg of an angle in contact back-to-back in a double angle member				b/t	9ε	10ε	15ε
Outstand leg of an angle with its back in continuous contact with another component							
Stem of a T-section, rolled or cut from a rolled I- or H-section				D/t	8ε	9ε	18ε

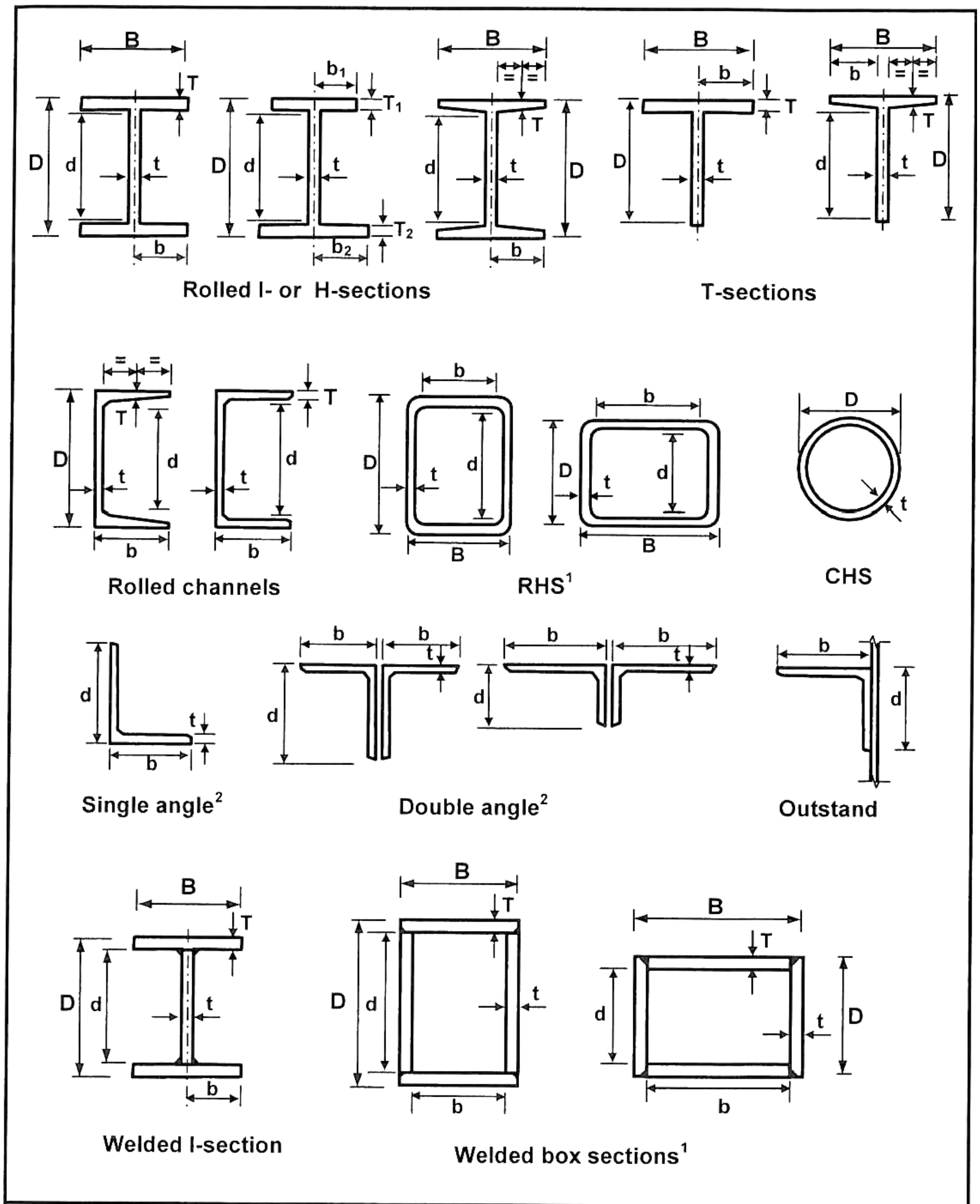
[a] Dimensions b, D, d, T and t are defined in Figure 7.1. For a box section b and T are flange dimensions and d and t are web dimensions, where the distinction between webs and flanges depends upon whether the box section is bent about its major axis or its minor axis, see clause 7.1.

[b] The parameter $\varepsilon = \sqrt{\frac{275}{p_y}}$ where p_y is in N/mm^2

[c] The stress ratios r_1 and r_2 are defined in clause 7.3.

[d] For the web of a hybrid section ε should be based on the design strength p_{yf} of the flanges.

Table 8 – Extract of Table 7.1 of HK Code[1]



[1] For a RHS or box section, B and b are flange dimensions and D and d are web dimensions. The distinction between webs and flanges depends upon whether the member is bent about its major axis or minor axis, see clause 7.1.
For a RHS, dimensions b and d are defined in footnote a to c Table 7.2.
[2] For an angle, b is the dimension of the outstand leg and d is the dimension of the connected leg.
Special care should be taken in sections fabricated by thick plates to avoid lamellar tearing.

Figure 7.1 - Dimensions of compression elements

Figure 9 – Extract of Figure 7.1 of HK Code[1]

2.11 National and International Code of Practice

The following design codes for structural steelwork are normally used /made reference to in Hong Kong.

- Code of Practice for Structural Use of Steel 2011.
- BS 5950 (2000) – Structural Use of Steelwork in Building, Part 1: Code of Practice for Design – Rolled and Welded Sections.
- GB 50017 (2003) – Code for Design of Steel Structures.
- BS EN 1993-1-1(2005) – Eurocode 3: Design of Steel Structures – Part 1-1: General Rules and Rules for Buildings.
- AS 4100 (1998) – Steel Structures.
- AISC - Load and Resistance Factor Design Specification 1999

3. Eurocode 3: Design of Steel Buildings (EN 1993-1-1, -1-3 & -1-8)

3.1 Background to the Eurocode Programme

The Eurocodes serve as reference documents that are recognized by European Union (EU) member states. They provide structural design rules that may be applied to complete structures and structural components and other products. Rules are provided for common forms of construction. The full suite of Eurocodes is as follows:

EN1990	Eurocode 0: Basis of Structural Design
EN1991	Eurocode 1: Actions on Structures
EN1992	Eurocode 2: Design of Concrete Structures
EN1993	Eurocode 3: Design of Steel Structures
EN1994	Eurocode 4: Design of Composite Steel and Concrete Structures
EN1995	Eurocode 5: Design of Timber Structures
EN1996	Eurocode 6: Design of Masonry Structures
EN1997	Eurocode 7: Geotechnical Design
EN1998	Eurocode 8: Design of Structures for Earthquake Resistance
EN1999	Eurocode 9: Design of Aluminium Structures

For structural steel design works, *EN1993 Eurocode 3: Design of Steel Structures*[8]*,* is adopted.

3.2 National Standards Implementing Eurocodes

The National Standard implementing Eurocodes (e.g. BS EN 1993-1-1 in UK) must comprise the full, unaltered text of that Eurocode, including all annexes (as published by CEN). This may then be preceded by a National Title Page and National Foreward, and maybe followed by a National Annex. The National Annex may only include information on those parameters (Nationally Determined Parameters (NDPs)) within clauses that have been left open for national choice.

3.3 Differences from HK Code / BS5950

The following tables summarize the differences on the definition of axes, wordings, symbols and load combinations between Eurocode 3 and the HK Code / BS5950:

	HK Code / BS5950	**Eurocode 3**
Along the member	-	X
Major axis	X	Y
Minor axis	Y	Z

Table 9 – Different Axes Definition of Eurocode 3[8] to HK Code[1]

HK Code / BS5950	**Eurocode 3**
Dead Load	Permanent Action
Imposed Load	Variable Action
Wind Load	Variable Action

Table 10 – Different Wordings of Eurocode 3[8] to HK Code[1]

If ψ=0.5 for W_k, ψ=0.7 for Q_k	**Dead G_k (Adverse)**	**Imposed Q_k (Adverse)**	**Wind W_k**
EN1990 (UK), Eq.6.10	1.35	1.5	0.75 (= 1.5 x 0.5)
	1.35	1.05 (= 1.5 x 0.7)	1.5
HK Code / BS5950	1.4	1.6	-
	1.2	1.2	1.2
	1.4	-	1.4

Table 11 – Different Load Combinations of Eurocode 3[8] to HK Code[1]

	HK Code	Eurocode 3
Cross-Sectional Area	A	A
Elastic Modulus	Z	W_{el}
Plastic Modulus	S	W_{pl}
Moment of Inertia (about major axis)	I_X	I_y
Moment of Inertia (about minor axis)	I_Y	I_z
Axial Load	P	N
Bending Moment (about major axis)	M_X	M_y
Shear Force	V	V
Wrapping Index	H	I_w
Polar Moment of Inertia	J	I_t
Yield Strength	p_y	f_y
Buckling Strength	p_b	$\chi_{LT}f_y$
Compressive Strength	p_c	χf_y
Radius of Gyration	r	i
Slenderness	λ	$\bar{\lambda}$

Table 12 – Different Symbols of Eurocode 3[8] to HK Code[1]

Revision

Read reference 2 on P.1 - 23.

Main Reference

1. *Code of Practice for Structural Use of Steel 2011, Buildings Department, the Government of HKSAR*
2. *Structural Steelwork, Design to Limit State Theory, 3rd edition (2004), Dennis Lam, Thien-Cheong Ang, Sing-Ping Chiew, Elsevier.*
3. *Limit States Design of Structural Steelwork, 3rd edition (2001), D.A. Nethercot, Spon Press.*
4. *The Behaviour and Design of Steel Structures to BS5950, 3rd edition (2001), N.S. Trahair, M.A. Bardford, D.A. Nethercot, Spon Press.*
5. *Steel Designers' Manual, 6th edition (2003), Oxford: Blackwell Science, Steel Construction Institute.*
6. *Structural Steelwork, Design to Limit State Theory, 2nd edition, T.J. MacGinley and T.C. Ang, Butterworths.*
7. *Explanatory Materials to Code of Practice for Structural Use of Steel, Buildings Department, the Government of the HKSAR.*
8. *EN1993 Eurocode 3: Design of Steel Structures*