Basic principles of steel structures

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Lecture Questionnaire (1)

Language preferred ( C = in Chinese,  E = in English)

<table>
<thead>
<tr>
<th>NO.</th>
<th>Oral Presentation</th>
<th>Writing on the blackboard</th>
<th>Handout &amp; textbook</th>
<th>Coursework &amp; written exam</th>
<th>Tick the one you prefer</th>
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From this course you prefer to:
Learn steel struc.  1  2  3  4  5  6  7  Practise
in English format  English
Syllabus

❖ Aims
To introduce procedures for designing steel members and connections.

❖ Syllabus (total 41 courses)
- Introduction => 2
- Steel properties => 6
- Tension members => 3
- Compression members (Columns) => 7
- Bending Members (Beams) => 8
- Beam-columns => 7
- Connections => 8

❖ Coursework & Assessment
- Assignment 1 Attendance, activities & Coursework 30%
- Assignment 2 Experiments EPUT 10%
- Assignment 3 Final written examination 60%
Introduction
Outlines

什么是钢结构？
为什么选择钢结构？
在哪里和何时使用钢结构？
主要结构类型
最先进的技术和潜在的市场
设计概念和钢结构的合理性
What’s steel structure?

architecture → structure → steel structure
STEEL STRUCTURE: A structure which is made from organised combination of structural steel members designed to carry loads and provide adequate rigidity.

Steel structure, reinforced concrete (RC) structure, concrete-filled-steel tubular (CFT) structure, steel-RC composite structure?

Steel structure? Yes, but steelwork of buildings, bridges and civil engineering works in this course.
What’s steel structure?

definition & scope

**steel structures** involve sub-structure or members in a building made from structural steel

SHANGHAI STADIUM
Steel roof + concrete stand

SHANGHAI GRAND THEATER
Steel roof + concrete columns
What’s steel structure?
definition & scope

structural member (构件) is physically distinguishable part of structure with independent structural function, e.g. member (杆件), element (板件), cable (索) and their combination.
Why use steel structure?

Advantages

- High strength
  The high ratio of strength to weight (the strength per unit weight)

- Excellent ductility and seismic resistance
  Withstand extensive deformation without failure even under high tensile stress

- Elasticity, uniformity of material
  Predictability of properties, close to design assumption

- Ease of fabrication and speed of erection
high ratio of strength to weight

By M.F. Ashby
Elasticity, ductility and uniformity of material
Ease of fabrication and speed of erection
Why use steel structure?

Disadvantages:

- Susceptibility to corrosion
  - Maintenance costs / thin-walled structure
- Loss of strength at elevated temperature
  - Fireproofing costs
- Susceptibility to buckling
  - Slender member in compression
- Fatigue and brittle fracture
Where & when use steel structures?

- Long-span structures
- Multi-storey & high-rise buildings
- Buildings of heavy duty plants
- Tower & mast structures
- Portal frames
- Bridges
- Infrastructures
- Deployable structures
- Generalized structures: mechanical
Long-span structures

- Airport terminals
- Train stations
- Theatres
- Exhibition centres
- Stadiums
High-rise buildings

Tai-ho 101

World trade centre

CCTV

Jinmao tower
Buildings of heavy duty plant
Tower & Mast structures

TV Tower

Eiffel Tower

TV Tower
Portal frames

Jiaochi II type double heat insulation composite plate
Bridges
Infrastructures
Agricultural buildings
Sight-seeing
Oh, he is coming...
Generalized structures
Main structural types
buildings and bridges

- truss structures
  - Bar or truss members
- frame structures
  - Beams and columns
- grids structures
  - Latticed structure or dome
- arch
- prestressed structures

- beam bridge
- truss bridge
  - Truss members
- arch bridge
- cable-stayed bridge
- suspension bridge
Main structural types
buildings: truss structures
Main structural types

buildings: frame structures
Main structural types
buildings: grid /domes
Main structural types
buildings: prestressed structures
Main structural types
buildings: prestressed structures
Main structural types

bridges: truss bridges
Main structural types
bridges: arch bridges
Main structural types
bridges: cable-stayed bridges
Main structural types

bridge: suspension structures
State-of-the-art & prospective market

technology & economy

☑ technology
  Accurate and automatic fabrication

☑ economy
  Less construction time and less structural weight

☑ environment
  Less wet work
  Reuse, Reduce & Recycle / removable
State-of-the-art & prospective market for steel structures

2007 y > overall output of the world before 1966

2008 y > 2nd-8th output

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<td>2~8 Sum.</td>
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State-of-the-art & prospective market for steel structures

Crude steel consumed kg/head

Forecast average 2017 = 550kg/head

Regional Kg/head 2006
- Coastal: 434
- Central: 227
- Western: 170

Kg/head 2017
- Coastal: 750
- Central: 450
- Western: 360

Data: CRU, NBS, CISA

Coastal
Central
Western

Kg/head 2006
Kg/head 2017

National average 2007 = 340kg/head

2007-2017
State-of-the-art & prospective market for steel structures

Steel structure → 4%

Residential Housing

China steel used in buildings

JAPAN

Residential Housing

Steel structure

2% → 4%

China construction area

2004

128,163

2000

80,715

Year


Wooden

R.C

Others
Design concept & rationale
ensure strength, stability and stiffness

- Stiff
- Strength
- Stability
- Light

→ All OK!

→ Not stiff enough (need bigger E)

→ Not stable enough

→ Not strong enough (need bigger $\sigma_y$)

→ Too heavy (need lower $\rho$)
Design concept & rationale

- **Loads**
- **Steel**
- **Member + connection**
- **Force, deformation**
- **Strength, stability, rigidity**

**S ≤ R**

Performance required: Safety, serviceability, durability
Design concept & rationale

Loads → action → structural model

- member → element
- connection → restraint
- actions → loading
Design concept & rationale

- member ? element
- connection ? restraint
- actions ? loading

Analytical model
Design concept & rationale

Loads

Mechanics of materials
Structural analysis
Elastic mechanics
Plastic mechanics
Design concept & rationale

Loads → action → structural system

Steel → metallurgy → fabrication → Member + connection

Force, deformation

Strength, stability, rigidity

$S \leq R$

Performance:
Safety, serviceability, durability
Design concept & rationale

- Steel
- Metallurgy
- Fabrication
- Member + connection
  - Strength, stability, rigidity
  - Tension member
  - Compression member
  - Beam
  - Beam-column connection

Mechanics of materials
You got a high level?
Design concept & rationale

Acceptable:
point of view of safety
point of view of economy
Design concept & rationale

DESIGN METHOD
— ASD

\[ \sum \psi S_n \leq \frac{R_n}{K} \]

— LRFD

\[ \sum \gamma_s \psi S_n \leq \frac{R_n}{\gamma_K} \]

\[ f_d \]

\[ S_a \quad S_n \quad R_n \quad R_a \]
Design concept & rationale

Fig. 1.15 Predictions of structural analyses

Fig. 1.12 Member behaviour
possible failure modes

☑ brittle / ductile fracture of steel members or connections
☑ global buckling of structures/members
☑ local buckling
☑ excessive development of plastic deformation
☑ loss of geometry stability
☑ fatigue failure
possible failure modes

brittle / ductile fracture of steel members or connections
possible failure modes

global buckling of structures/members
possible failure modes

local buckling
possible failure modes

excessive development of plastic deformation
possible failure modes

- loss of geometry stability
- fatigue failure
possible failure modes

your task:

Prevent all these failure modes