Steel

The Framework of Our Civilization

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Steel & Modern Civilization

Energy
Structures
Transportation
Drinking Water
Waste Management
Modern Steelmaking

Bessemer 1856

High-Volume Liquid Steelmaking

Siemens Open-Hearth Process 1858

Basic Oxygen Furnace (BOF) 1952

Electric Arc Furnace 1907
What Is a Metal?
It’s All About the Electrons
Phases of Iron

BCC

- Lower density
- Magnetic
- Stable

FCC

- Higher density
- Non-Magnetic
- Quasi-Stable
What is Steel?
Plain Carbon Steel

Iron + Carbon

= A Mixture of Phases

increasing carbon

100 μm

0.1 mm

100 μm
Where Does the Carbon Go?

**octahedral interstitials**

**FCC**

**tetrahedral interstitials**

**BCC**

- **Low-Carbon**
  - Up to 0.30 wt.% C

- **Medium-Carbon**
  - 0.3 to 0.60 wt.% C

- **High-Carbon**
  - 0.6 to 1.00 wt.% C

- **Ultrahigh-Carbon**
  - 1.25 to 2.0 wt.% C
Alloy Steel

Iron + other elements
= Special Properties

STAINLESS STEEL
10.5 to 30 wt.% chromium
→ Forms a protective oxide
How Does Steel Compare?
Structural Applications

- High strength
- Good ductility
- Fatigue resistant
- Cheap
Specialty Applications

- Nuclear reactor vessels
- Orthopedic implants
- Missile casings
- Tool steels
Why Does Steel Fail?
Impurities

The Sinking of the Titanic
Too much slag in the rivets?

Sank in 1912 (1,517 dead)
Wrong Type of Steel

Ductile to Brittle Transition

- Unique to ferritic steels
- Ductility lost at low temperatures
- 19 Liberty Ships sink in North Atlantic
Stress Corrosion Cracking

Steel Corrosion
- Salts & deicers
- Cyclic loads
- Sudden failure

Collapse of pedestrian bridge in NC in 2000 (106 injured)

Mianus Bridge collapse in CT in 1983 (3 dead, 5 injured)
Overloading

Too Much Traffic

- Aging bridges
- Increasing loads
- Insufficient maintenance

I-35 bridge over the Mississippi in 2007 (13 dead, 145 injured)
# Our Declining Infrastructure

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<td>Overall Need</td>
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Questions

1. What are things you do every day that you could not do without steel?
2. What are some ways that steel might have influenced societies ...
   ... in transportation?
   ... in exploration?
   ... in architecture?
   ... in warfare?
3. Why do you think the condition of our national infrastructure—much of which depends on steel—is in a poor or declining condition? What should be done about it? Why isn’t it being done? What can you do about it?