N-W.F.P. University of Engineering and Technology Peshawar

Lecture 02: Design Philosophies

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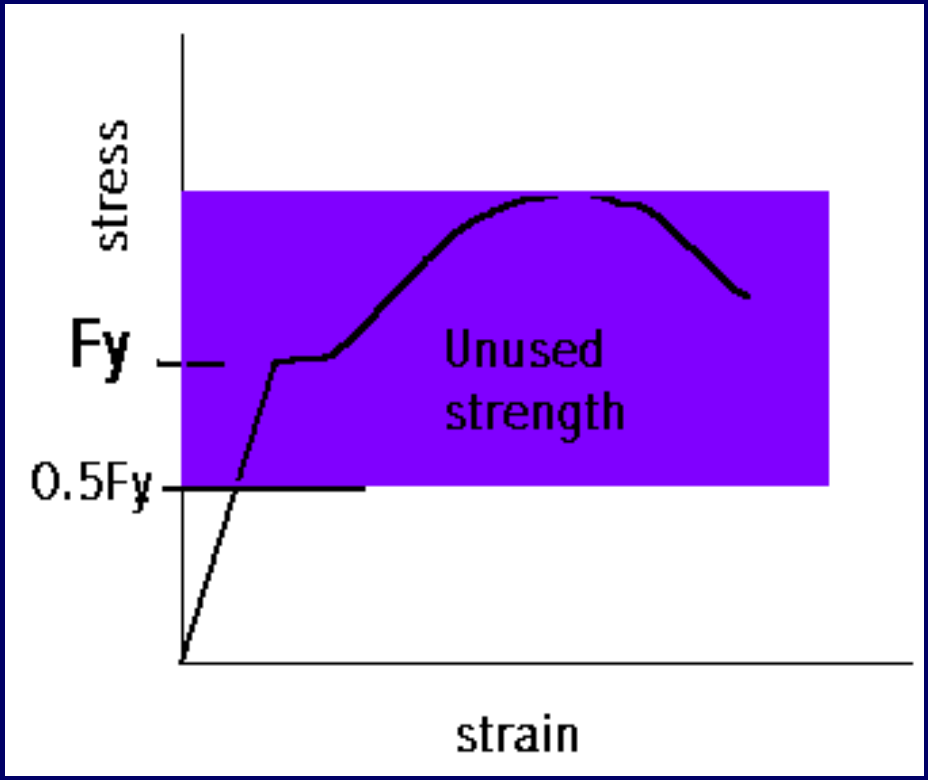
Topics to be covered

- Allowable Stress Design (ASD)
- Load and Resistance Factor Design (LRFD)
- Design process

Allowable Stress Design (ASD)

- Safety in the design is obtained by specifying, that the effect of the loads should produce stresses that is a fraction of the yield stress f_y, say one half.

Allowable Stress Design (ASD)



Allowable Stress Design (ASD)

- Since the specifications set limit on the stresses, it became allowable stress design (ASD).

- It is mostly reasonable where stresses are uniformly distributed over X-section (such on determinate trusses, arches, cables etc.)

Allowable Stress Design (ASD)

Mathematical Description of A S D

$$\frac{\phi R_n}{\gamma} \geq \sum Q_i$$

R_n = Resistance or Strength of the component being designed

Φ = Resistance Factor or Strength Reduction Factor

γ = Overload or Load Factors

$\frac{\gamma}{\phi}$ = Factor of Safety FS

Q_i = Effect of applied loads

Allowable Stress Design (ASD)

Mathematical Description of Allowable Stress Design

In ASD we check a design in terms of stresses therefore design checks are cast in terms of stresses for example if:

M_n = Nominal Flexural Strength of a Beam

M = Moment resulting from applied unfactored loads

FS = Factor of Safety

$$\frac{M_n}{FS} \geq M$$

ASD Drawbacks

- In the ASD method the assumption is, that the stress in the member is zero before any loads are applied.

ASD Drawbacks

- ASD does not give reasonable measure of strength, which is more fundamental measure of resistance than is allowable stress.
- Another drawback in ASD is that safety is applied only to stress level. Loads are considered to be deterministic (without variation).

Load and Resistance Factor Design (LRFD)

- To overcome the deficiencies of ASD, the LRFD method is based on:

Strength of Materials

- It consider the variability not only in resistance but also in the effects of load.
- It provides measure of safety related to probability of failure.

Load and Resistance Factor Design (LRFD)

$$\phi R_n \geq n \sum \gamma Q_i$$

R_n = Resistance or Strength of the component being designed

Q_i = Effect of Applied Loads

n = Takes into account ductility and redundancy.

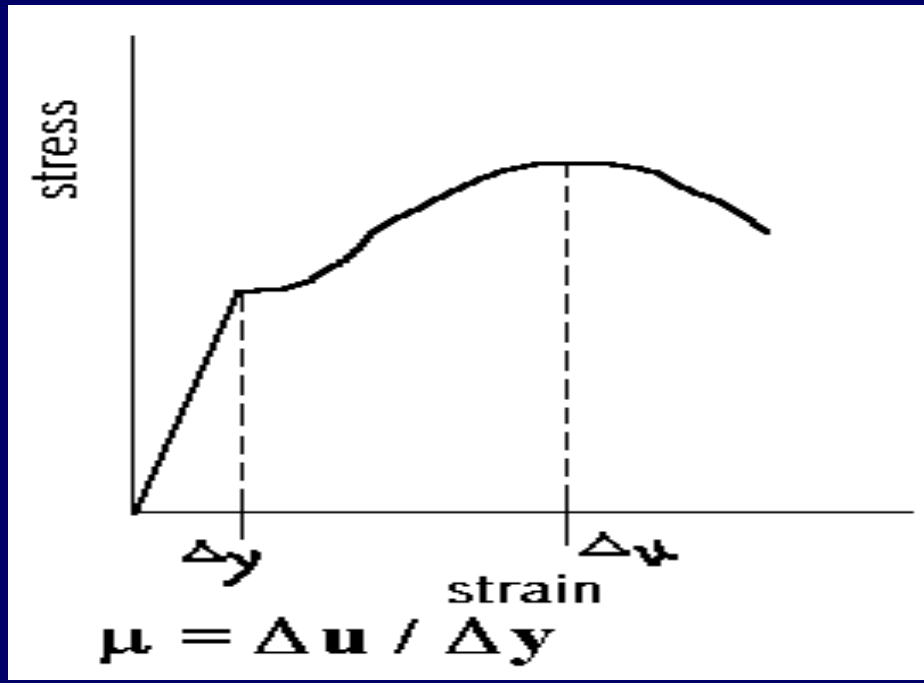
Φ = Resistance Factor or Strength Reduction Factor

γ = Overload or Load Factors

$\frac{\gamma}{\phi}$ = Factor of Safety

The role of ‘n’

Ductility: It implies a large capacity for inelastic deformation without rupture



The role of ‘n’

Redundancy:

1. A simply supported beam is a determinate structure so it has no redundant actions.
2. A fixed beam is indeterminate by 2 degrees so it has two redundant actions.

LRFD Advantages

- LRFD accounts for both variability in resistance and load.
- It achieves fairly uniform levels of safety for different limit states.

LRFD Disadvantages

- It’s disadvantage is change in design philosophy from previous method.

Comparison of ASD and LRFD Design Approaches

- ASD combines Dead and Live Loads and treats them in the same way
- In LRFD different load factors are assigned to Dead Loads and Live Loads
- Changes in load factors and resistance factors are much easier to make in LRFD compared to changing the allowable stress in ASD

Comparison of ASD and LRFD Design Approaches

- LRFD requires better understanding of behavior of the structure in its limit states
- Design approach similar to LRFD is being followed in Design of concrete structures in form of Ultimate Strength Design -- why not use similar approach design of steel structures?

Comparison of ASD and LRFD Design Approaches

- LRFD is more rational as different Factors of Safety can be assigned to different loadings such as Dead Loads, Live Loads, Earthquake Loads and Impact Loads

Comparison of ASD and LRFD Design Approaches

- LRFD considers variability not only in resistance but also in the effects of load which provides measure of safety related to probability of failure
- ASD still remains as a valid Design Method

The role of various Codes

- It is very difficult to give a design code that is applicable to all uses and all types of structures such as buildings, highway bridges, railway bridges and transmission towers.

The role of various Codes

- Critical loads may be different in different types of structures and no one code can cater to all the different important considerations
- For above reasons different codes exists and will continue to do so
- AISC(American institute of steel construction) ASD Code and LRFD Code primarily is pertinent to Building Structures.

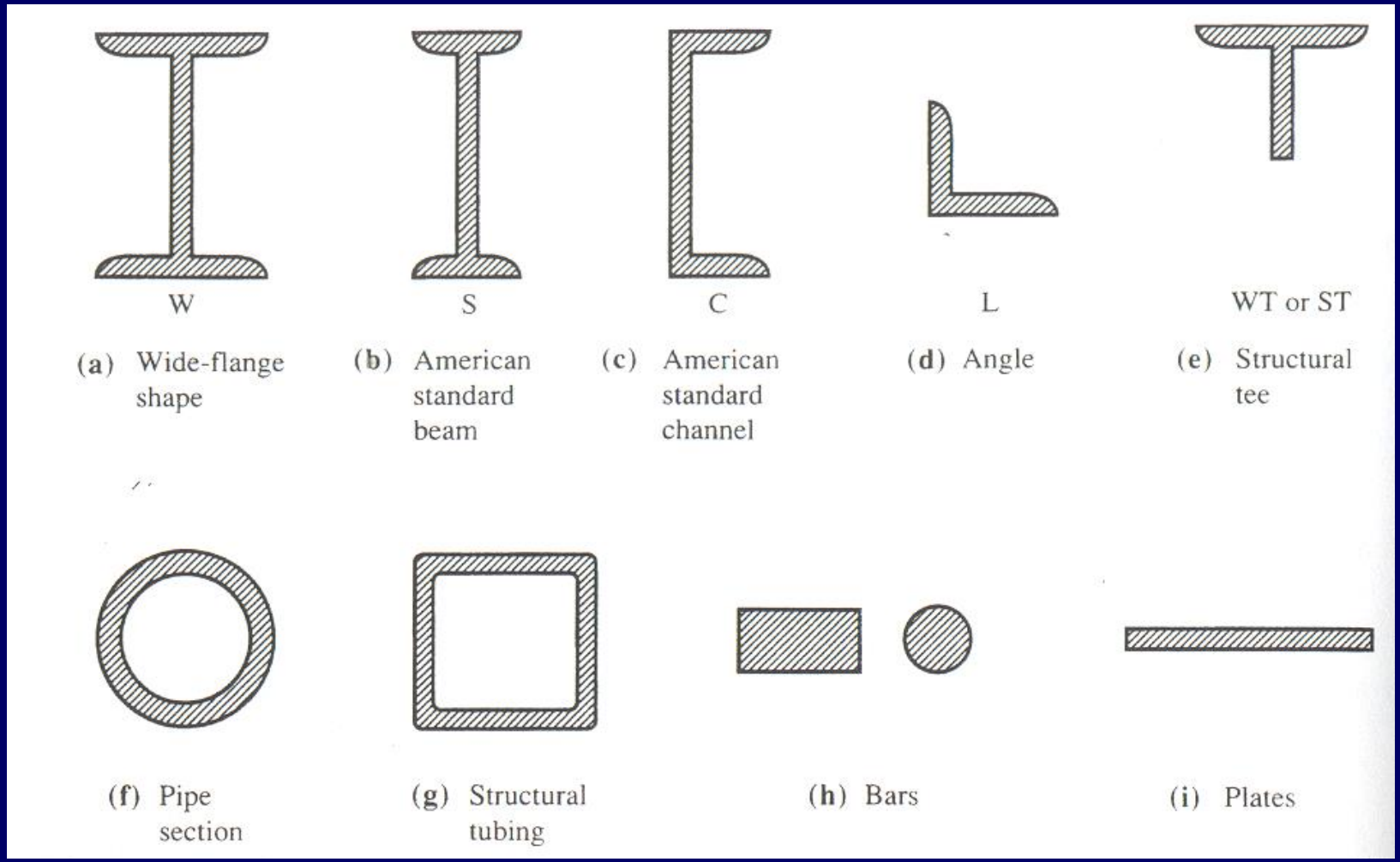
Mechanical Properties of Structural Steels

- Specification A6 outlines general requirements for Rolled Steel plates, shapes, sheet piling, and Bars for structural use.

- Specification A370 outlines the procedures for Mechanical testing of steel products.

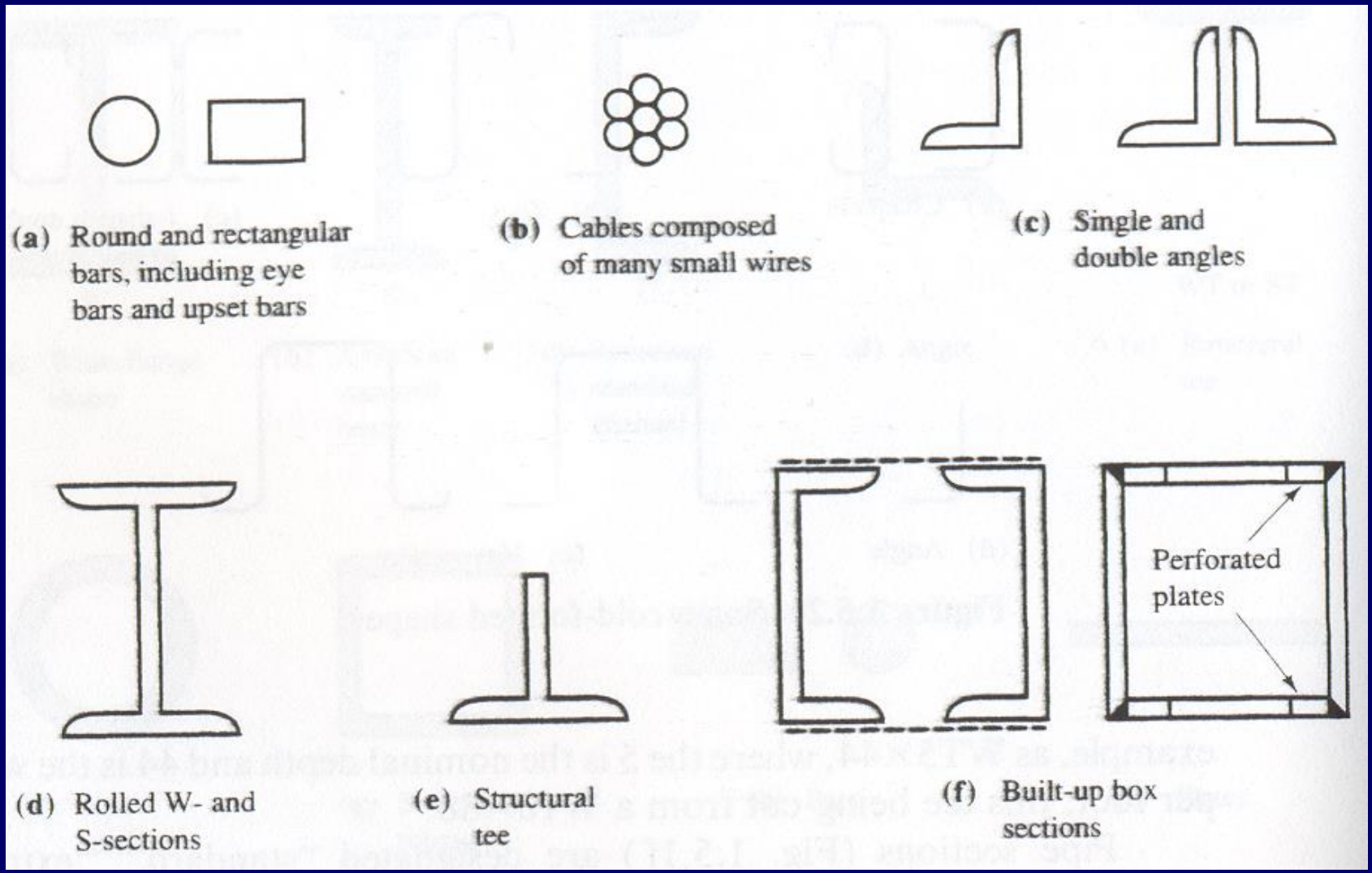
Types of Steel Shapes

Standard Rolled Shapes



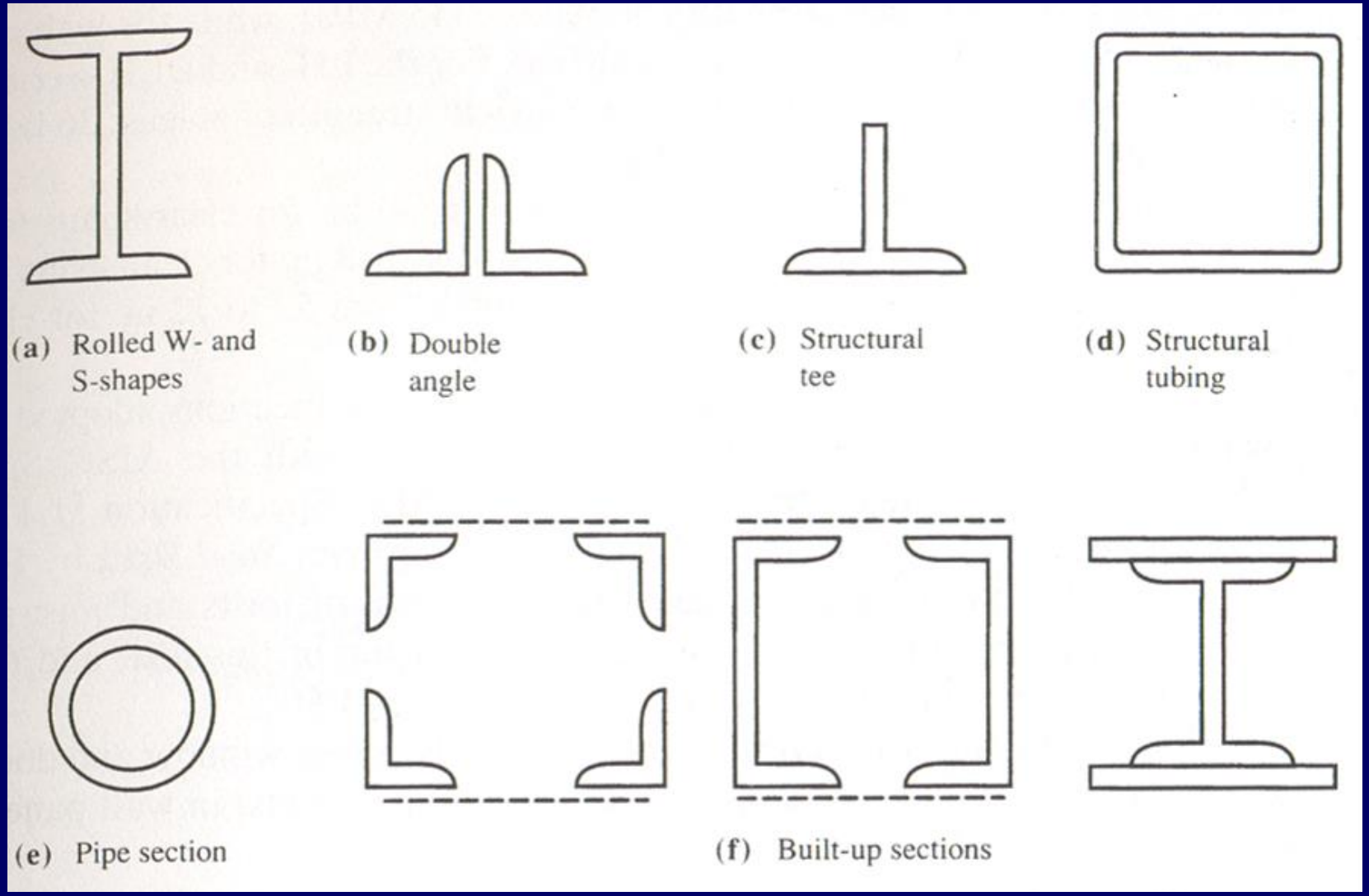
Types of Steel Shapes

Typical Tension Members



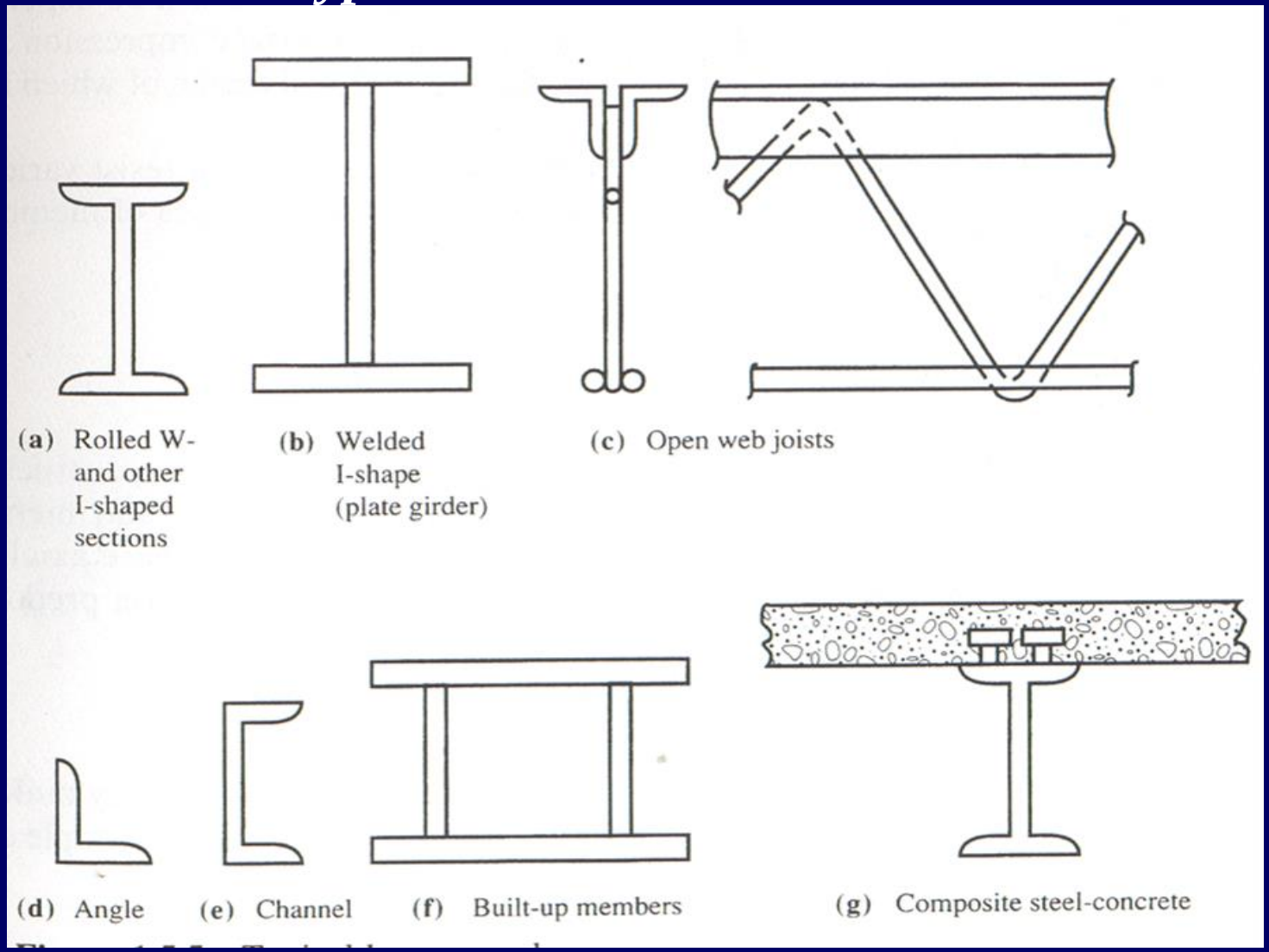
Types of Steel Shapes

Typical Compression Members



Types of Steel Shapes

Typical Beam Members



Types of Loads

Three broad categories:

1. Dead load
2. Live load
3. Environmental load

Types of Loads

1. Dead load

Dead Loads consist of the weight of all materials and fixed equipment incorporated into the building or other structure. (UBC Section 1602)

- Weight of structure
- Weight of permanent machinery etc.
- Dead loads can be reasonably estimated if the member dimensions and material densities are known.

Types of Loads

2. Live load:

Live loads are those loads produced by the use and occupancy of the building or other structure and do not include dead load, construction load, or environmental loads.

- Weight of people, furniture, machinery, goods in building.
- Weight of traffic on bridge

Types of Loads

2. Live load:

- Buildings serve such diverse purposes that it is extremely difficult to estimate suitable design loads.
- Different building codes specify live load requirements.
- Uniform Building Code (UBC)
- Southern Standard Building Code
- BOCA National Building Code

Types of Loads

2. Live load: (UBC Table 16-A)

Live loads for various occupancies	
Occupancy	Live load,psf
Residential	40
Libraries(reading room)	60
Mercantile	75-125
Heavy manufacturing	125-150
Light storage	120-125
Heavy storage	250 minimum

Types of loads

3. Environmental Loads

Environmental loads include wind load, snow load, rain load, earthquake load, and flood load.