材料と部材の力学

Chap.4: Concept of Stress

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1.1 Introduction

Analyzing and designing various load-bearing structures

Determination of stresses and deformations

Deflection – Deformation – Strain - Stress

変位 — 変形 — ひずみ — 応力

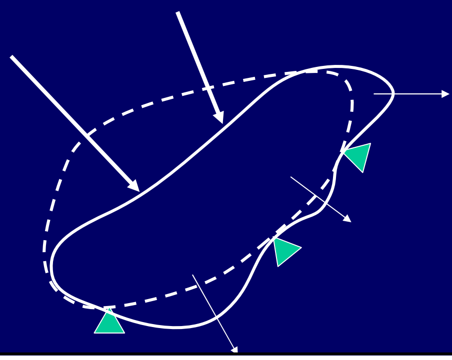
構造物に力が作用

|

変形

|

つりあい



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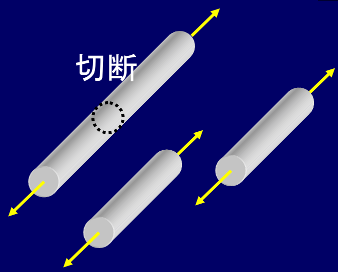
1.2 Stresses in the member of a structure

Forces and Stresses : 力と応力

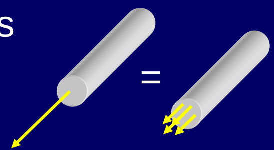


The force per unit area : 単位面積あたりの力

Intensity of the force

σ = P/A

Tensile stress + compressive stress



1 kPa=10^3 N/m^2

1 MPa=10^6 N/m^2

1 GPa=10^9 N/m^2

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1.3 Analysis and Design

Fig.1.1 の部材BCは鋼材で出来ている. この鋼材に対する許容応力度は165MPaである. この部材BCは安全に外力を支えることが出来るか？

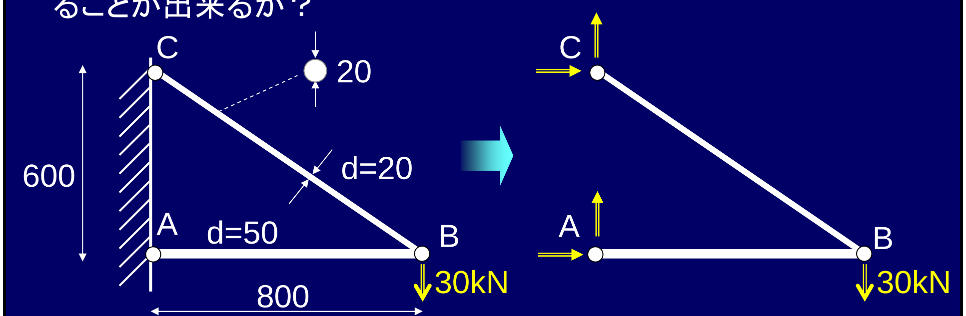

Fig.1.1　unit : mm　Free Body

もしもこの部材がアルミ製であるとすると, 安全に外力を支持するに必要な断面積は？

アルミの許容応力は100MPaである

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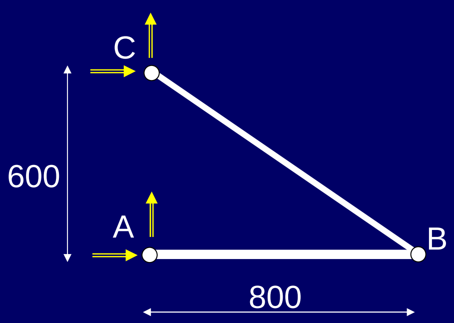
1.3 Analysis and Design



$$-T_{BC}\cos\theta - T_{AB} = 0$$

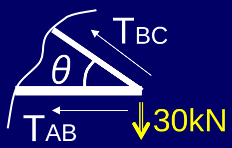
$$T_{BC}\sin\theta - 30 = 0$$

$$T_{BC}\,\frac{3}{5} = 30$$

$$\underline{T_{BC} = 50}$$

$$T_{AB} = -50 * \frac{4}{5}$$

$$\underline{T_{AB} = -40}$$



$$\sigma = \frac{T_{BC}}{A} = \frac{50000}{\pi(10^2)} = \underline{159\ \text{Mpa}}$$

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1.3 Analysis and Design

もしもこの部材がアルミ製であるとすると，安全に外力を支持するに必要な断面積は？

アルミの許容応力は100MPaである

$$\sigma = \frac{T_{BC}}{A} \qquad A = \frac{T_{BC}}{\sigma_{max}} = \frac{50\times10^3\ (\text{N})}{100\times10^6\ (\text{N/m}^2)} = 500\times10^{-6}(\text{m}^2)$$

$$= \underline{500(\text{mm}^2)}$$

$$A = \pi r^2$$

$$r = \sqrt{\frac{A}{\pi}} = 12.62(\text{mm}) \qquad d = w = \underline{25.2(\text{mm})}$$

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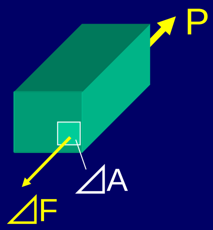
1.4 Axial Loading : Normal Stresses

The normal stress in a member under axial loading

$$\sigma = P/A$$



$$\int dF = \int_A \sigma \, dA$$

In practice, we shall assume that the distribution of normal stresses in an axially loaded members is uniform, except in the immediate vicinity of loading points

1.5 Shearing stresses

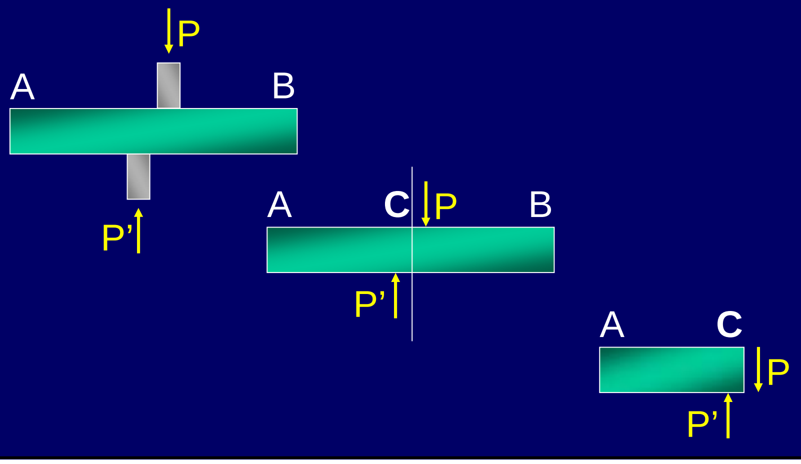
Shearing stresses are commonly found in bolts, rivets, pins used to connect structural members

ピン結合

ピン結合で構成された構造物

1.5 Shearing stresses

Passing section at **C** between the points of application of the two forces, we conclude that internal forces must exist and their resultant is equal to P



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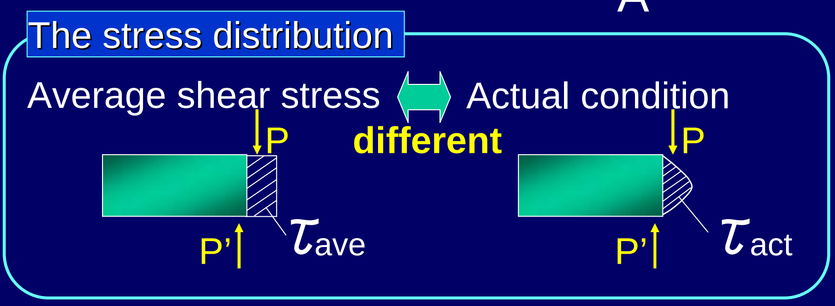
1.5 Shearing stresses (せん断応力)

Average shear stress : 平均せん断応力

$$\tau_{ave} = \frac{P}{A}$$



τ_{ave} is an approximately-employed expression for the design of structural members

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The rivet joint
Bolted Joint
Splice joint : 添接と呼ばれる

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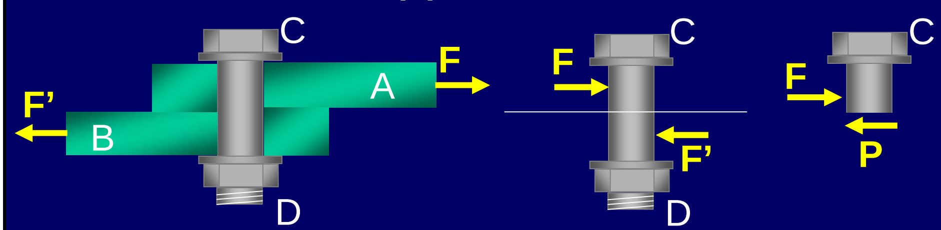
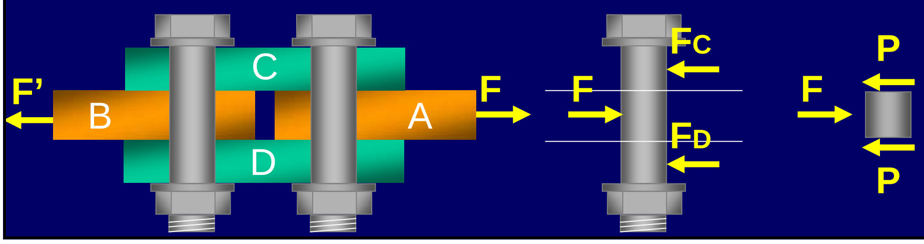
Single shear
片面添接

$$\tau_{ave} = \frac{F}{A}$$



Double shear
重要な継ぎ手　両面添接

$$\tau_{ave} = \frac{F}{2A}$$



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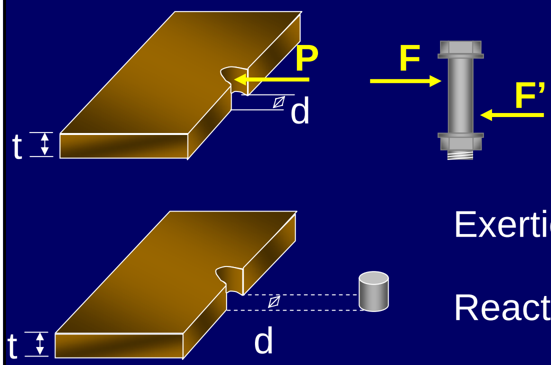
1.6 Bearing Stress in Connections
(継ぎ手部での支圧応力)

Bolts, rivets, and pins create stresses in the members along the bearing surface or surface of contact



Bearing stress

$$\sigma_b = \frac{P}{A} = \frac{P}{td}$$

Exertion of the bolt or rivet

Reaction forces at the hole

Suppose : The stresses are uniform in the hole wall

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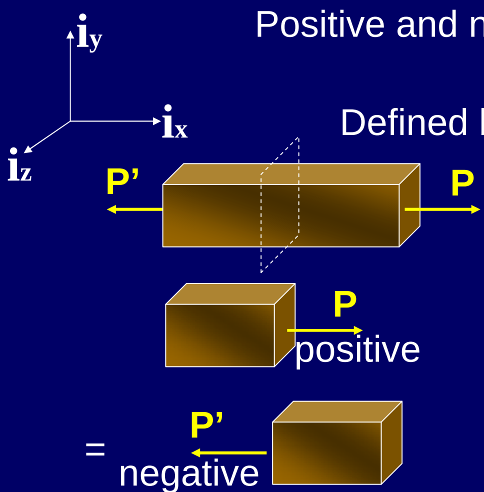
1.7 Stresses on an Oblique Plane under Axial Loading
(傾いた面上の応力:軸力作用下)

Positive and negative of the surface

Defined by the normal vector



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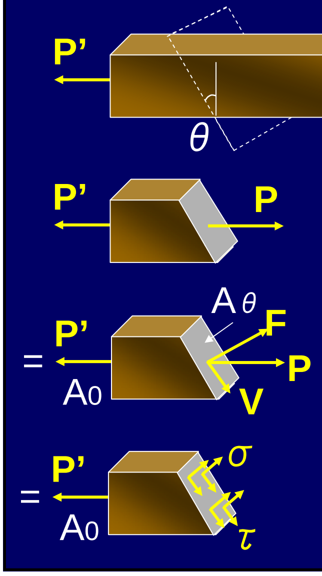
1.7 Stresses on an Oblique Plane under Axial Loading (傾いた面上の応力:軸力作用下)



Consider a section forming an angle θ

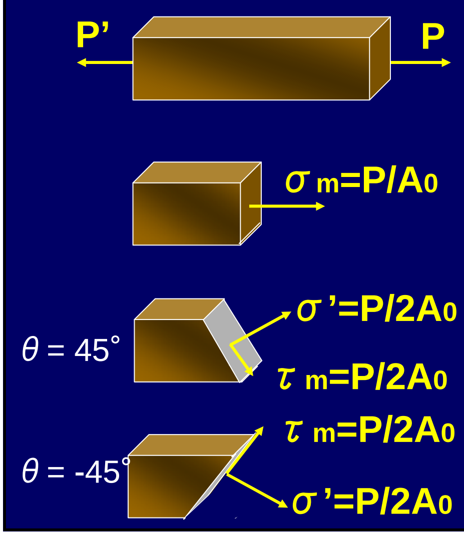
Draw the free-body diagram of a portion of member

Resolving P into F and V, respectively normal and tangential to the section , we have

$$F = P\cos\theta \quad V = P\sin\theta$$

$$\sigma = \frac{F}{A_\theta} \qquad \tau = \frac{V}{A_\theta}$$

1.7 Stresses on an Oblique Plane under Axial Loading (傾いた面上の応力:軸力作用下)



$$\sigma = \frac{P\cos\theta}{A_0/\cos\theta} = \frac{P}{A_0}\cos^2\theta$$

when $\theta = 0°$ $\quad \sigma_{max} = \frac{P}{A_0}$

$$\tau = \frac{P}{A_0}\sin\theta\cos\theta$$

$$= \frac{1}{2}\frac{P}{A_0}\sin 2\theta$$

when $\theta = 45°$ $\quad \tau_{max} = \frac{P}{2A_0}$